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William Ross

THE

Religious Philosopher:

OR,

The Right USE of Contemplating the

WORKS

OF THE

CREATOR

I. In the wonderful Structure of Animal Bodies, and in particular

II. In the no less wonderful and wife Formation of the E

and their various Effects upon Animal and Vegetable

III. In the most amazing Structure of the HEAVENS, with all

Design'd for the Conviction of Atheists and I

In Two VOLUMES.

Throughout which, all the late Discoveries in Anatomy, and Astronomy, together with the various Experiments in Philosophy of late Years, are most copiously handled by the Mathematician Dr. NIEUWENTYT.

Translated from the Low-Dutch

Author's prefix'd, a LETTER to the Translator by the

J. T. Desaguliers, LL. D. F. R. S.

The THIRD EDITION

Adorned with CUTS.

LONDON

M. DCC. XXIV

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III. In the moſt amazing Structure of the HEAVENS, with all its Furniture.

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Tranſlated from the LOW-DUTCH.

To which is prefix'd, a LETTER to the Tranſlator by the Reverend *J. T. Deſaguliers*, LL. D. *F. R. S.*

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LONDON:

Printed for THO. LONGMAN, at the *Ship* and *Black Swan* in *Pater-noſter-Row*.

M. DCC. XXIV.

Religio Medici:

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A. A. Daffanieu, LL. D. & R. S.

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To the Most Honourable

The * Lord *PARKER*,

Lord High Chancellor of *Great-Britain*, &c.

My Lord,

YOU gave an Intruder so kind a Reception at his first Address, that he is delighted with a Pretence to make you a second.

My first Attempt was to present Your Lordship with imperfect Copies, after my Manner, of the Originals of several Famous *French Philosophers*, drawn by one of the best Hands, that of the most Ingenious *Fontenelle*; than whom Sir *Godfrey Kneller*, our *British Apelles*, can hardly give an Object a more agreeable Likeness.

Now, my Lord, I am going to entertain You with a Picture of another kind, drawn by an honest plain *Dutch Philosopher*; *viz.* a *Sketch of Divine Wisdom and Providence*, display'd in the *Works of the Creation*; whose masterly Strokes affect the Mind with a due Admiration for the Original, which he has so well copied.

This Treatise of Philosophy the Author calls *The Right Use of the Contemplation of the World*, &c. Thro' the Whole of which there runs such a Strain of unaffected Piety, that I doubt not but his good Intentions (even tho' he had not executed them so well as he has done) must have already procured him the inward Satisfaction of that Glorious Promise made to the Father of the Faithful, and, thro' him, to all Believers, *I will be thy Shield and exceeding great Reward.*

My Lord, I beg leave to call the Learned Physician, who is my Author, the *Dutch* Ray or Derham, be-

* Now Earl of *Macclesfield.*

cause,

cauſe, like thoſe two *Engliſh* Philoſophers, he has ſo well prov'd the *Wiſdom*, *Power*, and *Goodneſs* of GOD by the ſtrongeſt *Arguments*, *Obſervations* on *Facts*, and *Demonſtrations* drawn from *Experiments*. It were to be wiſh'd, that he had apply'd the Texts of Scripture, which he quotes, as properly as he has done his Philoſophical Conſiderations: But ſince he has not ſo well ſucceeded in what may be call'd *his Divinity*, I have left ſeveral of the Texts out of this Tranſlation; but have retrench'd none of his Gloſſes upon the particular Texts by him quoted, nor any of his Glorious Tautologies, in which he does ſo often call upon *Atheiſts* and *Infidels*; excepting where his Comment is wrong, or the Repetitions are too tedious, and, I hope, unneceſſary, even for convincing of thoſe unhappy Men to whom he addreſſes himſelf; of whom it may be pronounced, that if they ſtill perſiſt in the Denial of a GOD, after ſo many irrefragable Arguments, drawn from the wonderful Structure of Humane Bodies, and all the other Glorious Works in the Univerſe, GOD will then *harden their Hearts*, and, like the Phariſees, they will not *be perſwaded, tho' one roſe from the Dead.*

However, my LORD, that I may not be thought to have acted raſhly in leaving out any thing of my Author's, I have in this followed the Advice of ſeveral of my learned Friends, *both Philoſophers and Divines*, (to whom I communicated ſome of theſe *Sheets* in MS.) and if I only ſaid that your Lordſhip approv'd of this deſign'd Omiſſion, the World wou'd be aſſur'd that I had conſulted a Philoſopher and a Divine: for as the *Royal Society* well know how Eminent your Lordſhip is in the firſt of theſe Qualifications; ſo many of the *Clergy* know, that a very able Prelate (now with GOD) and one mighty in Scripture-Learning, has openly profeſs'd, that *the Lord* PARKER *is one of the greateſt Divines in* England.

And

And here, my LORD, it may not be amiss to suggest to You, how great a Trouble I have met with, in teaching my Author to speak *English*; who by his affecting to express all his Technical Words or Terms of Art in his pure vernacular Tongue, such as, for instance, the *Veins*, *Arteries*, *Muscles*, *Fibres*, *Nerves*, and a thousand other *Anatomical*, *Physical*, and even *Mathematical* Words too, has made me take Pains unknown to my indolent Temper thro' the whole Course of my Life till now; for I have not been able to procure any Help in this Case, neither from the Living nor the Dead. Indeed the Tables and Figures of my Author (which are very curious, and taken from the most valuable Anatomists and Philosophers) have been of good use to me, where there are proper References; but those were the only Assistances I could procure here in *England*; so that for the rest, I should have been forced to guess at their Meaning, if my Learned Friend Mr. *'sGravesande*, *Professor* of *Mathematics* and *Experimental Philosophy* at *Leyden*, had not kindly interpreted to me those I could not unriddle: for there is no more Analogy between my Author's Terms and the *Latin* or *Greek* commonly used by all other Philosophers, than there is between them and *Hebrew* or *Arabic*. My LORD, I don't say this to praise myself or blame my Author, (who is rather to be commended for keeping up the Dignity of our Sister-Tongue, Daughter of the *Teutonic*, and Granddaughter of the *Gothic*, the common Spring of all the Western Languages of *Europe*, from North almost to South; and indeed we ourselves are not to be justify'd in losing and obsoleting so many of our most significant *Anglo-Saxon* Words and Phrases, as has been well observ'd before me by the Learned Mr. Baron *Fortescue*, *) but to lessen my own

* Now one of the Justices of the *King's Bench*. In his Ingenious Remarks upon the Lord Chancellor *Fortescue*'s Book, intituled, *The Difference between an Absolute and Limited Monarchy*. *Lond.* Printed for *E. Parker*, 1714. since reprinted, with Additions.

Fault,

Fault, and more eaſily to obtain your Lordſhip's Pardon, if the Difficulty of explaining thoſe Terms has made me commit any Blunders.

I can't conclude, my LORD, without endeavouring to prevent your Lordſhip in Favour of my Author, on account of one good Quality; which for being ſo rare and uncommon to moſt Writers, makes it appear the more lovely and charming in my Eyes: it is, that altho' he paſſionately endeavours throughout his whole Work (and repeats it ſo often, almoſt in every Section) to magnify the Wiſdom and Goodneſs of GOD, and to point out his Great Ends and Purpoſes in all the Works of the Creation; yet he is ſuch an Enemy to Pious Frauds, and to the ſupporting any of the Divine Attributes above-mentioned by wrong, or even doubtful and precarious Arguments, that he uſes none in confuting the *Atheiſt* and *Sceptic*, but ſuch as will bear even Mathematical Demonſtration: This has made him a little too ſtrict, it may be, in placing under the Claſs of *Things unknown*, the *Motion* of the *Earth*, and the reſt of the *Planets* about the *Sun*, as that great Philoſopher, Dr. *Clarke*, was pleas'd to obſerve, when I communicated to him the Contents of this Work; *That he could not but wonder extreamly, that in the 29th Contemplation, the Motion of the Earth ſhould be placed among Uncertainties, after that the Parallax of the Annual Motion is ſo notoriouſly apparent in the Phænomena of Comets*, &c.

But I forget, my LORD, that I am waſting thoſe precious Minutes which your Lordſhip employs ſo uſefully in the Service of your King and Country: That you may long employ them ſo, is the ſincere and hearty Wiſh of,

My LORD,

Your LORDSHIP'S

Weſtm. May 13. 1718.

Moſt obliged, faithful and moſt humble Servant,

J. Chamberlayne.

A

LETTER

FROM

*The Reverend * Mr.* DESAGULIERS *to* JOHN CHAMBERLAYNE, *Esq; relating to the following Treatise.*

SIR,

I HAVE read your Translation of Dr. *Nieuwentyt*'s excellent Treatise; and highly approve your Design of Publishing it, as it will be of great Service to *Religion* and *Philosophy*.

THE Doctor's Reason *that he gives* for writing his Book in *Dutch* (namely, that a great many Atheistical Books having been written in that Language, he chose to confute the Opposers of a Providence in the same) *will be* as powerful a Motive for the *translating it into* English; since we have not been behind-hand with our Neighbours in publishing the impious Conceptions and blasphemous Raillery of our Scoffers at Religion. If such of them as had been able, had *publish'd* their crude Notions in any of the learned Languages, their Books wou'd have needed no Answer, their Readers wou'd have despis'd them: But their Proselytes are gain'd among the Weak and Ignorant, or such conceited Debauchees as are glad to be supply'd with Means of defending their Immoralities, by attacking Religion with a shew of Wit and Argument.

WHEN an *Atheist* has the Impudence to call himself a PHILOSOPHER, some well-meaning Persons, that have not much look'd into Nature, are apt to be prejudic'd against the Study of it; as if the

* Now Doctor of Laws.

Philoso-

Philosophy and vain Deceit, against which the Apostle has warn'd us, had been the Contemplation of *the Works of the Creation*: Whereas it was only the Sophistry of the Schools, contriv'd to disguise Error, and defend the System of the superstitious Heathen Divinity.

He that reads *Nieuwentyt*, will easily see that a *Philosopher* cannot be an *Atheist*; and if it were true, that a Smattering in *Physics* will give a proud Man a Tincture of *Atheism*, a deep Search into Nature will certainly bring him back to a Religious Sense of God's Wisdom and Providence.

Tho' we have lately had several very good Books upon this Subject, this will not be less acceptable, because it contains several fine Observations and Experiments, which are altogether new, as is also his Manner of treating the most common *Phænomena*; from which he deduces admirable Consequences in favour of a Religious Life. And I think I may say this for the *Translation*, that it will perhaps do more Good than the Original; because in giving us all his Arguments for *Natural Religion*, you have omitted those which his too eager Zeal made him also draw from the *Modern Philosophy for Reveal'd Religion*; the Weakness of which latter might give those *Free-Thinkers* occasion to triumph, who would be struck dumb at Convictions from the former. If I can be of any Service in helping you to look over the Sheers, you may readily command, Sir,

Your most Humble

And Obedient Servant,

J. T. D.

Channel-Row, *Westm.* Feb. 2. 1713.

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THE

THE Author's Epiſtle TO THE READER.

THE *Deſign of Writing theſe* Contemplations, *is to convince* Athieſts *of the Wiſdom, Power and Goodneſs of* God, *the Maker and Ruler of all Things; and* Infidels (*who indeed acknowledge a God, but reject the Authority of the Holy Writings*) *that the Scriptures are of a more than Humane Original; and ſo to repreſent to both of 'em* the right Uſe of the Contemplation of the World.

The Methods we have made uſe of to prove the ſame, are only taken from the modern Obſervations, *and* probable Diſcoveries *in* Natural Philoſophy, *without laying down any bare Hypotheſes, ſince in the Things of natural Knowledge, we have no farther Foundation for Arguments than we can produce Experiments: Upon which, you may conſult the Writings and Plans of the* Royal Academies *and* Societies, *and of the moſt famous* Mathematicians *among them.*

The Reaſon why I have not made uſe of the Metaphyſicks, *&c. will appear in the* Preface, *Sect* 27.

While I was writing this, the Arch-Biſhop of Cambray's *Book fell into my Hands; and while I was compoſing the Preface, I met likewiſe with Mr.* Ray's *Book, tranſlated into* French; *and was moreover inform'd (tho' I don't underſtand the Language) that Mr.* Derham *had publiſhed another Book in* Engliſh, *wherein he largely*

proves the Being of a God upon the same Foundation. It was very agreeable to me to see and observe, that this Way of Proof, which I have always esteemed the strongest, was likewise embraced by such Great Men; in which, after all that is writ upon it, there still remains abundance of Matter, to convince the unfortunate Philosophers of the Perfections of their great Creator; and there will still remain enough to latest Posterity.

The Manner of proving the Divinity of the Holy Scripture from Natural Phenomena or Appearances, *which we here set before you, has not, that I know, been ever done before in such a Method. I hope, however, that the same may be of Use both to the* Atheist *and* Infidel, *because both those are wont chiefly to exercise themselves in the Study and Knowledge of Nature.*

The general Method of convincing both of 'em, is more largely represented in the following Preface, Sect. 29, 30 *and* 31.

I write in the Low-Dutch *Tongue, to the End that I may be more useful to my own Country-Men; and especially, because that Tongue has been often abused in Publishing and Dispersing* Atheistical *Books.*

The Order we follow, can in some Manner be learned from the Heads or Contents of this Work; tho' I have not confined my self very strictly to that which has been pursued by many others upon the same Subject.

Those who will read this Work as an Experimental Account of the Knowledge of Nature, *must not be offended at what we call the* Convictions, *which they frequently meet with, because our Design was not to write a Body of* Physicks *only, but to bring the Erroneous into the right Way; and by turning their Thoughts, after this Manner, to the Knowledge of Nature, to lead them on to the true Notions of the Deity.*

The able Mathematicians may perhaps think, that I ought to have proposed the Experimental Demonstrations, for Instance, of the Power of the Muscles, and *of the* Hydrostatical Laws in Fluids, *&c. in a more Mathematical Manner, or else barely to have related them without any farther Proofs, and so to have made the same Conclusions, without so much Trouble, and so many Figures; but they must be pleased to know, that I have deduced those Demonstrations as far as it was possible for me, by* Experiments *only, and not as the* Mathematicians *are used to do from* Establish'd Laws *of* Nature, *to the End that I might be the better understood by such as know little or nothing of the* Mathematicks. *I was indeed at first of a different Opinion, and had already prepared the whole Work without any Figures, and without Proofs, the Grounds of which were nevertheless very obvious to* Mathematicians. *But forasmuch as a certain Learned Gentleman, and after him several others objected, that if I did proceed in such a Method, many would think, that what I should advance in some Cases, was more incredible than true; and that in such great Matters one ought to bring at least as much Proof as would be necessary to confirm the Truth of one's Positions; I have therefore chosen to go on in that Way: This has likwise been the Reason why this Work, which I was forced to enlarge and alter in every Part almost, has seen the Light several Years later than it ought to have done, especially since my other Affairs have continually obstructed the same.*

They who upon good Grounds do acknowledge a God, and Divine Origin of the Holy Scriptures, will here find sufficient Proofs of their Confession; and those who are weaker,

weaker, may likewiſe, I hope, be confirmed in thoſe Truths againſt any Temptations.

But before I conclude this Addreſs to my Reader, I muſt entreat thoſe unhappy Philoſophers, *thoſe* wavering and doubtful Perſons, thoſe Infidels, *and much to be lamented* Strong Minds, *for whom this Work is chiefly calculated, that they would come prepared to conſider the ſame, not ſo much with an acute, as with a ſerious Judgment, and decent Reſpect for ſo momentous an Enquiry; and not ſo much to obſerve what Difficulties may occur in ſome Paticulars, as whether there is not ſomething in ſuch a Number of Things as may ſerve to convince them of the Perfections of their Maker, and of the Authority of his Word. If they proceed in the firſt Way, the ſtrongeſt Proofs will be of no Uſe to them; but if they fall into the latter, one ſingle Fact weighed by a Mind in earneſt, and diſpoſed to learn, may, by God's Bleſſing, convince them of their Errors.*

The Thetical *Way, which is only made uſe of here for their Conviction, muſt not appear imperfect to them, as if it did not ſufficiently confute their Sentiments, but let them compare it with their own Poſitions, and judge themſelves, whether a Proof deduced from certain and actual Experiments, which is the Caſe here, ought not to be more convincing, than that which is grounded upon naked Ideas; which, without any actual Experience to ſupport them, are arbitrarily advanced for Notions of things really exiſting, and that their Philoſophy is only built upon this latter Foundation, they themſelves muſt know. Accordingly, the ſophiſtical Arguments of thoſe Atheiſts, and the not only falſe, but horrible Conſequences flowing from their Opinions, have been already fully expoſed by divers eminent Perſons, to whoſe Writings we refer you.*

If there ſhould be any thing among all theſe Contemplations, in which, according to the Opinion of the Reader, I may have been miſtaken, and have not rightly repreſented the Properties of the Natural Phœnomena, *let him paſs it over, ſince he will not be able to ſay the ſame of all the reſt; and in caſe he allow one ſingle Proof to be ſtrong enough among ſo many as are here brought together, or of thoſe whereof the farther* Contemplation of the World *may yet ſuggeſt a much greater Number to him, that alone will be powerful enough to convince any Man, that argues rationally, of the Being of a God, and of the great Origin of his Word, ſince one Demonſtration proves as ſtrongly as ſeveral, tho' more do ſtrengthen the Conviction.*

Neither let the Quotations of Scripture-Texts in theſe Diſcourſes, make you reject the whole Work without reading it, as many are uſed to do when they meet with them in any Books, ſince the Divinity thereof is not here ſuppoſed, but proved; and that ſome of them ſerve to ſhew the Wiſdom and deep Knowledge in Nature of him that inſpired them; and others, to convince you that no Man, tho' never ſo underſtanding, nor any Impoſtor, tho' ever ſo cunning, either for Political Reaſons, or otherwiſe, was capable to produce in thoſe Times ſuch things as we find written therein; from whence you may eaſily conclude who has been the Author of them.

Let not the Atheiſts and Unbelievers conceive a Prejudice againſt this Work, ſince they may learn not only from the Title, but from thoſe ſincere Aſſurances we hereby give them, that we did not write it out of the leaſt Hate or Contempt of them, but from a hearty Sorrow for their miſerable Condition, and only in order to their Converſion;

ſion; for which Reaſon, I have commonly made them themſelves the Judges of the moſt part of my Concluſions; I therefore only intreat them, that they would paſs their Judgment upon what is here ſubmitted to it, without that deplorable Reſolution taken up by many of thoſe who call themſelves Strong-Minds, *or* Free-Thinkers, *not to acknowledge the Being of a God.*

One of theſe Poſitions muſt be irrefragably true (it being impoſſible to lay down a Third) either that, according to their Opinion, all Things in the World are govern'd by Chance, *and by* Neceſſary Laws, *without the Intervention of an Intelligent Being, and that the* Chriſtian Bible *is compoſed by* Cheats *and* Impoſtors, *who had no other View but their own Advantage; or elſe, that the* Holy Scriptures *are given by a* God *that* Governs *the* World, *and who will require an Account from thoſe Creatures whom he has endued with Reaſon, how they have uſed the ſame.* Let them therefore conſider how much it imports them not to be miſtaken in thoſe things, whereon their eternal Welfare or Miſery depends; and let them judge whether it be not at leaſt as true, that they and the World are made by a wiſe God, as that a Clock, or any other ingenious Piece of Workmanſhip, does prove the Skill of the Maker. *Upon all which, if they ſeriouſly contemplate, they will tremble at their own Notions; and ſince it is a Matter of Fact, and not a meer Speculation that is in queſtion, and ought to be examined, whether it be not neceſſary to enquire into the Things themſelves, without relying upon naked and atheiſtical Notions; 'tis for this End theſe* Contemplations *are written. May the Almighty* GOD, *who alone can over-rule our Minds and Thoughts, enforce theſe and other Proofs, in which the whole World abounds!*

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THE PREFACE, OR INTRODUCTION, TO THE Following *Contemplations* of the WORLD.

SECTION I. *The true Difference between Atheists, and those that fear GOD.*

IT is hardly credible, that there were ever any Men, who had not quite lost their Understanding, so foolish and unreasonable as to deny an *Eternal* and *Self-existent Being*, and to maintain that there has been a perfect State of *Inanity* or *Nothingness*, in which there were neither *Creator* nor *Creatures*; for even the most Famous among the Ancients, and *Spinoza* himself among the Moderns, tho' they may justly be rank'd with the *Atheists*, have yet acknowledged an *Eternal Being*.

The great Difference therefore between *Atheists*, and those who confess and fear a *God*, is not whether there be such a Being, which from all Eternity has subsisted by himself (for that is owned by them all, at least by all that I have ever heard of) but whether this Eternal Being is also *Wise*, *Powerful*, and *Merciful*; and whether he has made all things according to his own Pleasure, for certain Ends and Purposes, and does continually direct and govern the same.

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It is true indeed, that those miserable Wretches find themselves obliged, in some Manner, to confess his *Power*, were it only from their daily observing, with their own Eyes, what great Bodies are moved in the Heavens with an unspeakable Swiftness; and perhaps also, they might own his *Goodness* and *Mercy*, if we allow them to explain it in their own Sense, and to ascribe the Goodness of this Being only to the happy Qualities of Things, making use therein of their own Understanding, by which they think they are able to convert most Things that occur to them in the World to their own Advantage, and to render them subservient to their own Necessities and Pleasures: But with great Difficulty will they allow, upon their Principles, that this Eternal Being is *Wise*, and orders all Things according to his own good Pleasure; because such a Concession would be entirely inconsistent and contradictory, as well to *a meer Chance*, as to all the *unknown Laws of Nature or Necessity*: This is also the only Foundation of their continual Uneasiness and Terror; since if this Being is *Wise*, and knows that they endeavour blasphemously to rob him of his Attributes and Perfections, they may easily conclude what will be their Reward hereafter.

That this was likewise the old Question in former Ages, may be inferr'd from the Writings of *Cicero* about it; where the Disputations of the Philosophers, by him introduc'd, do not so much turn upon the *Existence* of a *God* (meaning thereby such an Eternal Being) as concerning *the Nature of the Gods*. It may therefore seem strange, perhaps, to those who from their Youth upwards have been so happy as always to acknowledge and reverence God for their Almighty Lord, Maker, and Supporter, out of a Conviction of is adorable Perfections, to hear that there can be found a Set of Men, who owning an Eternal Being, or the Existence of a God, do nevertheless consider him as deprived or divested of the above-mention'd Attributes: And yet that both the former and latter Times have swarmed with such deplorable Genius's, is too well known to fill this Book with the Relations of them. We shall therefore satisfy our selves with acquainting the Reader, that the following *Contemplations* are expresly calculated to bring these unfortunate Men, if it be possible, to better Thoughts.

Sect. II. *In order to bring Atheists to Reason, it is necessary to enquire into the Causes and Remedies of Atheism.*

That we may therefore take the true Methods to arrive at this great End, it seems necessary in the first Place, seriously to enquire what are the real Causes that many fall into such deplorable and irregular Opinions concerning this Tremendous and Eternal Being; and when we have come at the Knowledge thereof, to find proper Remedies to prevent the same.

But the Reader is desired to take Notice, that we do not intend to treat of this Matter in its utmost Extent: we shall satisfy our selves only to collect such of the Causes of Modern *Atheism*, which we have experimentally observed to prevail over the Minds of these ungodly Disputers, and from thence suggest such Means, as the same Experience has taught us to apply with good Success against this lamented Evil.

SECT. III. *The First Cause is* Inordinate Self-Love.

THE first Cause therefore, and which mostly prevails in the Nature of Men, is usually the *Passion of a too extensive and inordinate Self-Love.*

From hence only it is, that Men desire to gratify their Inclinations, and to be in Subjection to no body; and if they cannot be exempted altogether from the latter, they wou'd have it be no other kind of Subjection than what is agreeable to their Carnal Appetites. Wherefore, hearing that there is a God, and that he is Just and Holy, and will be obey'd by them in all things, and will certainly punish those his Creatures that refuse to acknowledge his Power, they earnestly wish to be entirely freed from it.

This induces them to turn a deaf Ear towards all the Convictions of such a Being; and forasmuch as their Consciences, in spight of all their Endeavours, will not suffer them to be easy, they are continually seeking out for Arguments, whereby they may perswade themselves of the contrary; and so stifle the dreadful Remorses of such their resisting Consciences. For these Reasons did the blind Heathens ascribe to their Gods, *Passions* and *Inclinations* like those which they felt in themselves; pretending, that those Gods delighted in *Drunkenness*, *Fornication*, *Adultery*, and other irregular Affections.

To look for no farther Proof of what has been advanced, let every Man who has been so unhappy as to hunt for Arguments to darken and blot out of his Mind the Knowledge of the Perfections of his Creator, retire into himself, and examine, whether if that, which is received by Christians for the Word of God, and in which his Will is contained, should allow him to abandon himself to all his Inclinations in this Life, and should promise him the Enjoyment of the like Pleasures through all Eternity, he would not endeavour with as much Zeal and Diligence to find out Reasons whereby to convince himself, and every Man besides, that there is a *God*, and that the *Bible* is his revealed Word, as he now Attempts to make himself, and others believe, that the same is false. There is, however, an innate Desire in every Man to become happy: Does he expect to find this in the Knowledge of a God? then will he extend his Desires that way: But perceiving, that by the Acknowledgment of a Supreme Holy Being, he would consequently be obliged to renounce his Sinful Pleasures, he will wish that there was no such thing as such a God; tho' he dares not own the same, least he should be found out by others for what he really is, a miserable *Atheist*.

I appeal for the Truth of what I have here said, to those Men who have ever lived in these sad Doubts and Uncertainties, and in the mean time followed their Passions as far as they could, without incurring the Punishment of the Temporal Magistrate, and without Prejudice of their good Name or Estate, but have at last attained to a better Mind. It is not necessary to produce Examples of those, who after their Conversion have openly avow'd the same, tho' I could easily do it.

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SECT. IV. *The Means to prevent this inordinate Self-Love.*

NOW ſince this whole Miſtake is nothing elſe but a Paſſion that hurries them away without the leaſt Foundation or Shadow of Reaſon, many of this kind of *Atheiſts* are reduced to the right Way, when God (who in all theſe Caſes muſt be acknowledged to be the firſt Cauſe) ſhall pleaſe to ſanctify the Means that are uſed thereto; which, beſides the increaſe of Years, that often calms the impetuous Paſſions of Youth, do likewiſe ſometimes conſiſt herein, to wit, that they be brought to a right and ſerious Conſideration of the *Wiſdom*, *Power*, and *Goodneſs* of *God*, which undeniably manifeſt themſelves in the *Contemplation* of the *World*, and the Government of all Things in a multifarious Manner, to ſuch as are not reſolved to remain wilfully blind; eſpecially, if the corrupt State of themſelves, and of all Mankind, and the Vanity of thoſe Things upon which they beſtow the Name of Pleaſure, be ſet before them in a proper Light; and eſpecially that unhappy Condition in which all Men would find themſelves, if, according to their own Opinion, the World were govern'd either by meer Chance, or by the Laws of blind Fatality. Finally, how dreadful would it be for them in caſe their deplorable Notions (for I cannot beſtow a better Term upon them, ſince no body can prove them) ſhould be entirely falſe. By which Conſiderations a lower Value for preſent, and a greater Concern for future Things, would be produced in their Minds; which being oppoſed to their former Paſſions, might contribute to extinguiſh the ſame, and awaken in them ſuch ſerious Thoughts, as ſometimes are alone ſufficient to make them change their Opinions.

SECT. V. *The Second Cauſe is Inordinate Ambition.*

THE ſecond Cauſe of *Atheiſm* is another Paſſion, conſiſting in an *irregular Ambition, which ariſes from the ſame Source of Self-love, by which ſome, having once abandoned themſelves to the Defence of ſuch unfortunate Sentiments, fancy that they ought therefore to paſs with other Men for Perſons wiſer, and of greater Underſtandings*; and ſo they beſtow upon each other the Appellation of *Eſprits Forts*, that is to ſay, *Strong-Minds*, or *Free-Thinkers*; being, as it were, deſirous to ſhew thereby, that they are ſuch ſtout and couragious Men, as are not to be terrified with vain Fears or Bugbears (as they term it) like the Vulgar and Childiſh People.

This is one of the higheſt Steps to which *Atheiſm* can attain, and indeed it cannot well climb higher; becauſe, when it is once arrived to that paſs, it does not only ſlight all Convictions, but ſo long as this Paſſion and inordinate Ambition continues, compels Men neceſſarily to reject them, and conſequently to remain altogether incurable. For whereas the firſt ſort of *Atheiſm*, which is only founded upon the Enjoyment of Pleaſures, may be ſilently oppoſed and conquer'd as ſoon as any contrary Argument begin to make an Impreſſion, this laſt has moreover this Obſtacle and Hindrance in the removing it, that thoſe who have once maintain'd it, altho' they ſhould change their Mind, are afraid of loſing their imaginary Eſteem, and the Ho-

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nour of a ſuperior Wiſdom and Knowledge, and of being henceforwards accounted by thoſe that know them, not only Cowardly and Unconſtant, but likewiſe Men of miſtaken Judgments: It being commonly the way of theſe conceited Strong-Minds, or Free-Thinkers, to ſpeak contemptuouſly of all that ſee their own Errors, and have Virtue enough to forſake them. Now how powerful the Fear of Contempt is over ſome Men who have a great Conceit of themſelves, we are taught by daily Experience in many Caſes; inſomuch, that this unhappy ſort of Creatures have been often obſerved to break forth into dreadful Blaſphemies, only to give a Proof of their greater Knowledge and Penetration, and to avoid the Suſpicion of ſpeaking againſt their Conſciences, and of diſſembling their juſt Fears.

Sect. VI. *The Remedy againſt this Evil.*

I Have ſeldom ſeen any Humane Means made uſe of with Effect againſt thoſe who will not be convinced; ſince this kind of *Atheiſm* is attended, for the moſt part, with great Ignorance; and that thoſe miſerable Wretches who are tainted with it, can be ſeldom brought to liſten carefully to the Arguments objected againſt them; being accuſtomed to anſwer the beſt and ſtrongeſt Proofs with Contempt and a ſcornful Smile, not judging them worthy of a better Return from their ſuperior Underſtandings. Yea, whatever may be the Occaſion of ſuch an exceſſive hardneſs and ſtiffneſs of Heart, it is viſible that they lie under a dreadful Judgment of that God whom they have ſo unrighteouſly blaſphemed, and ſo far as one may gueſs from Circumſtances, do often continue ſo to the End, unleſs the ſame merciful God be pleaſed to take Pity on them, and make them unconceivable Miracles of his Grace.

Among ſuch, I knew one, who having been adviſed by a Friend (for he was deaf to all other kind of Proofs) ſeriouſly to conſider himſelf, his Soul, and Body, and all that happen'd in the World round about him, began to perceive, that it was hardly to be believed, that he himſelf, and all beſides him, could be made and govern'd by any thing but a Being endowed with great Wiſdom: So that a little while before he died, he heartily thanked his Friend for the Counſel he had given him, and deteſting his former wicked Thoughts with a Flood of Tears, he continued to his Death to beg Forgiveneſs of that God, whom all his Life-time he had refuſed to acknowledge, praiſing, with his laſt Breath, the unexpreſſible great Mercy of his Divine Majeſty, who had vouchſafed to look upon ſuch an abominable Creature, that had deſerved nothing but his Wrath and Vengeance, with the Eyes of Mercy. I have known others of this kind, ſome of whom have in a harden'd Manner drowned themſelves; others, that have taken Poiſon, and the reſt ended their Lives in the utmoſt Diſpair upon their Sick-Beds.

Sect. VII. *Concerning the Death of* Spinoſa.

Upon this Occaſion of mentioning the miſerable Deaths of ſeveral Atheiſts, I cannot forbear to take Notice of what has been related, and with great Truth, as far as I could diſcover, touching that of *Spinoſa*; that he

ended his Life in Solitude and great Tranquility, without manifesting any external Signs of Uneasiness. This, I know, seem'd strange to some Weak, but Pious, Men, who had either seen or heard of very different and most dreadful Judgments of God against some that had thus denied him; and, secondly, that the Followers of this same *Spinosa*, took an occasion from thence to think, that the Opinions of their Master were not so unjustifiable. But for the Satisfaction of the former, they ought to be told, that God, working with Freedom, does not always punish Sins so visibly in this Life; and as for the latter, if they have been conversant in the Writings of that *Atheist*, they may observe from thence, that *Spinosa* is not so much to be looked upon for a learned Disputant, as for such a sort of an *Atheist*, who with or without Conviction, was resolved simply to adhere to his wicked Opinions; because, as he thought, they would make him pass his Life more agreeably.

I would not have it thought, that I say this of him out of Prejudice, but refer to his own Words, in his 34th Letter to the *Heer van Blyenbergh*; where he says, first, that he does not understand the Holy Scriptures, and entirely acquiesces in the Suggestions of his own Understanding; and then (instead of proving the Certainty thereof, which would have become a true Philosopher to have done upon such an occasion) he proceeds thus, in a very unworthy Manner, to speak to some Body that is seeking after Truth: *And altho' what I have already advanced concerning the Natural Understanding, should appear to be false; yet I am happy, whilst I enjoy my Opinion, and pass my Life easily, merrily, and pleasantly, without Tears and Sighs*, &c. Now let wise Men judge, whether these Words shew a Philosopher seeking after Truth, or an obstinate *Atheist*, that will not be convinced, least it should spoil his Mirth: It cannot therefore be denied, that God may suffer a stubborn Blasphemer to fall away so far, that by persisting a long time in his Errors he becomes at last entirely blind, and so remains, till the impending Wrath of God shall open his Eyes.

It is, moreover, very certain, that to the end he might not be disturbed (I mean *Spinosa*) he would not admit of any Discourse, whilst he lay upon his Sick and Death-bed, with any Body about the State of Men after this Life, and the Certainty or Uncertainty of his own Opinions; which also does not look like the real Convictions of a true Philosopher: For tho' his Judgment might be so weaken'd by the Violence of his Sickness, that he could not well weigh nor answer the Reasons and Objections that might be brought against him to his own Satisfaction; it was nevertheless true, upon his Principles, that he would not therefore be the more unhappy after his Death; but only that he could not have flatter'd and delighted himself with the Honour of passing for a greater *Free-Thinker* than other Men.

Lastly, I may here add, that one of his most particular Friends and Disciples (well known to me in my Youth) who always adher'd to his Opinions, and maintain'd them, when he durst, with great Acuteness, being a Man of very good Parts, lying upon his Sick-bed, and remaining there in a long Silence and Indolence, in Imitation of his Master, did at last burst out

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in these dreadful Expressions, *That he now believed all that he had formerly denied, but that it was too late for him to hope for Mercy.* This was related to me, concerning the dreadful End of this Man, with all its Circumstances, by a certain learned Gentleman, who knew that I having been acquainted a great many Years with the Opinions of that unfortunate Creature, and hearing of his Death, should be desirous to be informed of the Circumstances thereof.

Now whether the Followers of *Spinosa*, after having well consider'd all that has been said concerning the last End of their Master, have any Grounds for their Indolence and Indifferency, I leave it to themselves to consider; provided they will do it without Passion and Partiality.

Sect. VIII. *The third Cause is Ignorance.*

A Third Cause of these deplorable Opinions seems to be, in some Men, a *downright Ignorance.* Accordingly I have met with some, who having never exercised their Understandings in examining Matters, have blindly followed their Inclinations in all things, so far as their Opportunities, which were few enough, would give them leave; and who being asked, what they thought of the *World*, and of its *Beginning?* openly denied that a God had made it.

I knew one of this sort, who, after having abandon'd himself to Drunkenness for many Years, and passed his ignorant and brutish Life in these destructive Notions, died in the same, at least it appeared so to them that attended him during his last Illness, and that related it to me.

I met also with another, that might justly be ranked among the Number of these ignorant Persons, who tho' he was outwardly a regular and sober Person, yet when he was in the Company of those that were not very averse to his Opinions, did not scruple to speak out plainly, and to affirm, that every thing *was from Nature* (this was his Expression) *so as it is:* And when he was pressed more closely to explain himself, alledged no other Reason, than that it appeared so to him, and that he could not conceive it otherwise; affecting, at the same time, under this Darkness and Ignorance a certain Haughtiness, as if his Understanding was much superior to that of others.

Sect. IX. *Means to prevent this Evil.*

Now, for the Conversion of this Sort of *Atheists*, since the best *Metaphysical* Arguments make no Impression on them, forasmuch as they do not conceive them, nor will give themselves the Trouble to study them, nothing seems to me more useful than to set before them such Proofs as are only founded in those common Experiments, obvious to every Man's Sight; and I know that one of this last Sort, who could not easily be induced to discover any Weakness or Doubts in his Opinions, was thereby obliged to acknowledge, that such Proofs made him a little uneasie.

SECT. X. *The fourth Cause is too great a Conceit of one's own Wisdom.*

THE Fourth Cause of *Atheism*, as far as my Observations and Experience reach, proceeds from *a too great Conceit of our own Wisdom, and from an implicit admitting that to be Truth, which we are wont to deduce from our own Ideas or Notions.* And some Men are apt to advance such their Notions with great Arrogancy, as well concerning the Divine Attributes and Properties, as about the smallest Appearances in the Creatures: In short, they except nothing, and pretend to reduce every thing to an infallible Rule of Possibility and Impossibility, Truth and Falshood, Good and Evil.

This is the most dangerous Kind of all: *First*, Because they deny every thing that they do not conceive; and therefore all Divine Revelation (which is above their Understanding) is not only rejected by them, but ridicul'd also. *Secondly*, Because they have the greatest Opportunity to support their Errors with specious and plausible Arguments, and to evade the Force of those Objections that are brought against them, which they immediately make use of as soon as their Adversary commits the least Oversight or Blunder. *Thirdly*, Because many of them, in their Conversation, do assume an external Appearance of Morality, and other Social Virtues, whereby they sometimes acquire a certain Esteem with the Ignorant, which may be of dangerous Consequence; the rather, because divers of them having learned the Elements of *Euclid*, *Algebra*, and other speculative Parts of the *Mathematicks*, pass amongst the Unknowing for great *Mathematicians*; which Title does really no more belong to them, than that of a great Philosopher to one that understands nothing but a little *Logick*; since People may be very well experienced in these Ideal or Notional Sciences, and yet be Masters of very little or no Knowledge at all in Things that actually exist and come to pass.

But we must not from hence conclude, that such noble Studies do of themselves lead those miserable Men into such erroneous Opinions; for these, in many Cases, open the Way *to the Discovery of the Wisdom of God in the Works of the Creation*, to which we could not otherwise attain: On the contrary, they are exceeding useful, unless when misapply'd by these half-learned Men, who being puffed up with a little Knowledge, fancy they know every Thing, and despise all those who do not just understand as much as they themselves about *Lines* and *Quantities*, tho' they be much wiser, and more judicious in other Kinds of Learning.

SECT. XI. Spinosa *briefly confuted.*

THUS we find at present, that in order to make even *Atheistical* Writings to pass for uncontroverted Truths, the Authors thereof have endeavour'd to give them the Form of Mathematical Demonstrations. A remarkable Instance of which may be seen in the Book of *Spinosa*, which has for that Reason gained so much Credit with many of these unhappy Persons; because those who do not rightly understand the *Mathematicks*, judge from the External Appearances,

pearances, that what is laid down therein is deduced from juſt *Mathematical* Principles.

Perhaps we may hereafter find an Opportunity more fully to ſhew the Miſtakes that are there advanced under the Name of *Demonſtrations*, when we ſhall compare 'em with ſuch as are truly *Mathematical*.

To ſay a Word or two thereof *en paſſent*:

1. There are two Kinds of Objects, about which the *Mathematicians* do treat or employ themſelves, *viz.* Ideas ſimply conſidered as ſuch, and Ideas of Things really exiſting; that is, to ſpeak more clearly, *Mathematicians* diſcourſe either only about their Ideas, or elſe about Things that are really exiſting out of their Ideas.

2. The firſt Manner is ſeen in the *Speculative Geometry*, ſuch as the Elements of *Euclid*, *Algebra*, *&c.* where they conceive a Point as ſomething that has no Parts, a Line without Breadth, *&c.* So likewiſe they here conſider Magnitudes, which have more than three Dimenſions, *&c.* which every Body knows are only certain Ways of our Conceptions, having no real Exiſtence out of them.

3. The ſecond Kind of Object occurs in *Aſtronomy*, *Opticks*, *&c.* where things are conſidered, which, beſides our Ideas of them, have a real Exiſtence in themſelves.

4. The Foundation of the Firſt, beſides *Axioms*, are *Definitions*, in which they deſcribe their Ideas, without troubling themſelves whether there is any thing really exiſting that agrees therewith: Inſtances of which we have juſt now given: Accordingly it is with them a Truth, that *the three Angles of a Triangle are equal to two Right ones*, and wou'd ſtill be ſo, altho' every Thing in the World were circular, and that there were not really ſuch a Thing as a Triangle.

5. The other way is founded upon Experiments and Diſcoveries, which either they themſelves, or other creditable Perſons make of Things which are out of their Ideas, and ſomething more than meer Conceptions. Thus a good *Aſtronomer* lays down for the Foundation of his Science, that which he, or thoſe whom he can believe, have experimentally diſcover'd, namely, that there is really ſuch a Thing as a *Globe* of the *Earth*, a *Sun*, a viſible *Moon*, five *Planets*, ſome of which have their *Satellites*, or Bodies circulating about them, and a great Number of fix'd *Stars*; but does by no means extend his Imagination or Fancy to the Suppoſition of other Worlds, and other ſorts of Bodies; as for Inſtance, that there are ten Suns, a hundred Moons, a thouſand Planets, and a very few fixed Stars; of which imaginary Worlds, he might nevertheleſs bring a great many Proofs, which according to the firſt Way of arguing, we may allow to be mathematical enough, but when adapted to the Things themſelves, would appear to be entirely falſe.

6 Now thoſe that have read and underſtood *Spinoſa*, are ſenſible that he only lays down his own Ideas and Notions for the Foundation of every thing, which therefore needs not to be farther proved here: From whence it may appear to every one, that he applies this manner of diſcovering Truths preposterouſly to Things really exiſting, of which true *Mathematicians* never make

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uſe, but only about their own Ideas; wherefore the whole Series of ſo many Hypotheſes and pretended Demonſtrations in *Spinoſa*'s Book (tho' he ſhould argue rightly upon thoſe Principles, of which, however, the contrary may be proved in many Caſes) do repreſent nothing elſe to us than only the Properties of thoſe Imaginations or Conceptions, which that unhappy Author had formed in himſelf; nor can any Man thereby conclude any thing more from the Things themſelves, than an Aſtronomer can do, who advances his own Notions for the true Structure of the Heavens.

7. So that from this Miſtake alone the Weakneſs of all *Spinoſa*'s Arguments appears at one View, and how little his Way of Demonſtrating agrees with that of true Mathematicians.

Sect. XII. *The Remedies againſt this Fourth Cauſe.*

But to return from this Digreſſion: Since theſe unhappy Philoſophers aſcribe ſo much to their own Underſtanding, and do exert their whole Strength to oppoſe the Weight of all *Metaphyſical* Arguments, tho' they are ſupported by ſtrong Reaſons, the only Way that I have ever ſeen uſed with Succeſs to overthrow their proud Fancies that they can conceive every Thing, and to ſhew them the Narrowneſs of their Underſtandings (which is particularly neceſſary to their Converſion) is this; let them be brought into a *Chymical Laboratory*, or other Places where People are wont to make Phyſical Experiments, ſuch as are not commonly known to every Body, and let them be asked what will be the Reſult of ſuch, or ſuch an Operation, purſuant to their own Notions and Conceptions? In which, if they miſtake, and Things appear quite contrary to what they expected, they can have no Subterfuge or Evaſion, but will be compell'd to acknowledge, that their Underſtandings have been very little converſant upon Objects really exiſting: And in caſe they themſelves are verſed in Natural Experiments, let them be deſired to contemplate, without Prejudice, the Manner how every thing they ſee comes to paſs, and to think whether the Power and Wiſdom of the Great Creator and Ruler of all Things, does not appear as inconteſtably in them, as the Judgment and Skill of any Artificer in the Machines that he has invented.

Sect. XIII. *The firſt Steps to Atheiſm are Prejudices.*

Besides the above-mention'd four Cauſes, there do occur to me other Steps or Inducements to *Atheiſm*; which tho' they cannot properly be eſteem'd *Cauſes*, as the former, yet they are uſed by many as Steps towards it; and tho' they do not always bring Men to deny, yet they do at leaſt tempt them to doubt of the higheſt Truths.

The firſt Sort of theſe are our *Prejudices*, ſome of which we bring into the World along with us, as others proceed from the Slaviſhneſs of our External Senſes. Thus Men fancy, for Inſtance, that the Sun is no bigger than a Trencher, or little Diſh, and that its Diſtance from us is very ſmall: In the ſame Manner the Planets appear to us as little contemptible Things. This being deeply impreſſed in our Minds, tempts us to look upon the Greatneſs of God with very ſmall Reſpect or Reverence; ſince from ſuch Appearances

we

we judge there was very little Power neceſſary to form and govern them: Whereas, if we did (as we ought to do) conſider the World in its immeaſurable Expanſion, the Sun as a Globe of Fire, of a moſt amazing Bigneſs, and the Planets as ſo many thouſand times bigger than this whole Earth, they would excite in us quite other ſorts of Conceptions, and make us ſtand abaſhed at the great Power of our adoreable Creator and Ruler.

Another *Prejudice*, which hinders us from obſerving the Wiſdom of God in the Direction of the viſible World, is, that when we cannot ſee either *Bodies* or *Motions*, we are preſently apt to fancy that there is nothing either of Body or Motion, but what we can ſee with our own Eyes; for believing that that which is at Reſt will always remain ſo, and that nothing elſe is requiſite to continue it, it ſeems to us as if neither Power nor Direction were neceſſary thereto, and that Fancy inſenſibly leads us either to deny altogether, or at leaſt hardly to acknowledge any Divine Providence in thoſe Things and Places. Thus do many imagine, that in a Chamber, for Inſtance, which is full of Light and Air, all Things are ſtill and quiet, and conſequently, that there is no Want in that Place of any Power and Wiſdom to preſerve us from Accidents: But if one were to repreſent to ſuch Men the incredible Strength of the Air ſurrounding them, and that without the Intervention of a Wiſe and Powerful Being, which continually reſtrains its reſiſtleſs Violence by a Counterpoiſe and Ballance of Force, they would be cruſhed to Pieces in an inſtant; and ſo if they were made to conceive the terrible Motions of Light, which unleſs it were govern'd by certain Laws, by which its Rays are ſeparated and ſcatter'd, would, in the Space of a few Minutes, put this whole Globe of the Earth in a devouring Conflagration; who could doubt, if he had the leaſt Spark of Reaſon in him, that he has not from hence the juſteſt Cauſe imaginable to praiſe and extol the *Greatneſs*, *Power* and *Wiſdom* of a God, who only preſerves us from all thoſe Dangers, and hinders us from periſhing in ſo miſerable a Manner.

Sect. XIV. *The Means to cure Men of theſe Prejudices.*

Now in order to be cured of theſe *Prejudices*, we are taught, by what has been already ſaid, that it is neceſſary to enquire experimentally into the true State and Nature of Things, and afterwards to form a right Notion of them from thoſe Proofs which are drawn from undeniable Experiments, and frequently to meditate upon the ſame; this will make us, as it were, feel with our Hands the Power of the great Ruler of all Things, if we do but carefully attend thereto.

Sect. XV. *The ſecond Step, the abſurd or wrong Manner of deſcribing Nature.*

The ſecond Inducement or Inlet to *Atheiſm* (tho' upon many Occaſions it is in it ſelf uſeful and neceſſary, but by an imprudent Application ſerves to corrupt Mens Underſtandings) is an *abſurd and falſe Manner of Philoſophiſing*, or rather *of Inſtructing any one in the Knowledge of Nature*; under which Head I refer, in the firſt Place, to ſuch ſort of Books, as perhaps are not written with an evil Deſign, but which, however, if you will believe the Authors them-

themſelves, pretend to give a true Notion of the whole Frame and Conſtruction of the World, and of all its viſible and inviſible Parts, without Exception; deſcribing, after their Manner, with as much Aſſurance as if they had been preſent, and were GOD ALMIGHTY's Cabinet-Council, how he made the World, how he put all Things together, and how he has produced and continued the Motion thereof; and (which I have often been ſurprized to hear from the Mouths of ſuch as were otherwiſe Men of good Senſe) even how every Thing between the Circumference of the ſtarry Heavens, and the Centre thereof, were made in the Beginning of the World.

Now, if ſo be that any Man ſhould fall into ſuch an unhappy Opinion, as to receive for Truth all that he finds written in ſuch Books, how can he do otherwiſe than believe, that there was no more Wiſdom requiſite to bring this glorious Frame of the World into ſuch a beautiful Order as we ſee it, and to continue it in the ſame, than what the Authors of ſuch Books were Maſters of? And how far this may in time miſlead a great many young and unexperienced Perſons, and divert them from that Wonder and Reverence which is due to the endleſs Wiſdom of GOD, it is eaſie to imagine, and ſome have found by fatal Experience.

SECT. XVI. *The Inconveniencies of Deducing every Thing from an Hypotheſis.*

TO this wrong Way of Thinking may be aſcribed *the Manner of Deducing all the Phœnomena of Nature from a certain Hypotheſis.* Now it will be very eaſie to ſhew, how many Occaſions of falling into irreverent Thoughts of GOD's all-ruling Providence, this imaginary Manner of Philoſophiſing furniſhes Men with; ſince ſome Underſtandings obſerving that it coſts them more Pains to comprehend any notable *Mathematical* Propoſition, or to ſolve an *Algebraical* Queſtion, than to repreſent to themſelves the Cauſes and Operations of all that belongs to the viſible World, upon the Foot of ſuch an Hypotheſis; the great Work of the whole Creation appears to them more eaſily to be conceived than ſome of the Inventions of the *Mathematicians:* From whence therefore a tacit Conſequence is deduced by little and little, that towards the Conſtruction and Government of the Heavens and the Earth, leſs Wiſdom is required, than what many Perſons, whom they look upon to be great *Mathematicians*, are really poſſeſſed of; and this does proportionably diminiſh the Reverence which they ought to have for the Wiſdom of their Great Creator; the Loſs of which is oftentimes one Stone of Offence, upon which ſome of my Acquaintance have firſt ſtumbled, and afterwards fallen.

Thoſe who have been intangled in ſuch a Labyrinth, are wont zealouſly to engage themſelves yet farther therein, and, againſt all the Convictions of contrary Experiments, to ſupport their Hypotheſes with all their Might; perſwading themſelves, with a ſecret Pleaſure, that without beſtowing any Trouble or Charges upon Trials, their own Hypotheſes will ſerve them for a true Key to open the moſt hidden Secrets of Nature: And to the end that they may not be brought into any Doubtings concerning the ſame, from this Obſervation, that there may be more than one Hypotheſis from which the ſame

Effects

Effects are deducible (as is known in *Astronomy* and other Cases) many of 'em are accustomed to lay down this Maxim, *That an Hypothesis may be safely maintained to be the most true, because it is the most simple*; which Argument is of much the same Force, as if any one seeing a Watch going in a Chamber, pretends to have rightly proved, that the same is moved by a *Weight*, and not by a *Spring*, because the former of these appears to be the most plain and simple.

Finally, this Hypothetical Philosophy is so much the more prejudicial, as it necessarily obliges Men to fancy that they have attained to a fundamental Knowledge of even the most principal Things that occur in Nature; since every one must expect to be look'd upon as a compleat Fool, in case he presumed to find out an Hypothesis which was proper to account for Phœnomena wholly unknown to him; forasmuch as any Alteration in the *Phœnomena* must likewise necessarily produce Alterations in the *Hypothesis*; and this cannot be done without occasioning too mean an Opinion of the Works of our Great Creator, and even of the Creator himself.

To disentangle themselves out of such a Labyrinth, more Pains are requisite than a Man who has never tried it can perhaps imagine; especially, if such Persons be pretty far embarked in these Studies. Every one who has had the Trial of it, knows how mortifying it is to give up an Hypothesis which he has believed and maintained for many Years to be true, upon which he has pored and meditated so many Nights, with which he has blotted so much Paper, and for the sake of it, ran thro' so many Books; and, lastly, by the help of which, he fancies to himself, that he is arrived to the Top of all Wisdom, or at least, that he shall soon reach it. He that has a mind to see an Instance thereof, let him peruse the Preface to the *Anatomy of the Brain*, by the Learned Dr. *Willis*.

Sect. XVII. *The Remedies against this Evil.*

Now, in order to prevent the being seduced by this manner of Philosophising by Hypotheses only, it is first necessary, that Men should not dwell too long upon those speculative Studies, tho' they should silently flatter us with the Fruitfulness of such Hypotheses, and the Representation of the Greatness of out Understanding; but we should give our selves up to actual Experiments, not enquiring into the Opinions of Men, but into the Nature of Things themselves, and satisfy our selves of the *Power* and *Wisdom* of the adoreable Creator, after a quite different and more positive Manner, and learn how great is the Difference between *knowing* any thing *Experimentally*, and *guessing* at it *Hypothetically*.

Sect. XVIII. *Another Remedy.*

Another Way whereby we may secure our selves against the Evil Consequences of this kind of Studies, is, when we are asked about Things of which our Ideas are not sufficiently clear, to answer calmly, and without blushing, *I know not*; and by no means pretending by this, or that uncertain, or undemonstrated Hypothesis, to give an Account thereof, for fear of losing the respect that belongs to us. This will prevent the naturally high Conceptions

ons which we have of our own Understanding, from throwing Dust in our Eyes; and it is the true Means to make us think humbly of our selves, and to contemplate with Wonder the Works of our great Creator.

I know very well how hard a Thing it is for one, who has an Opinion of the Fame of his own Learning, and who has devoted himself to these Studies, to be brought to a frank Confession, *that there is something which he does not know*; the rather, because this or that Hypothesis may seem always to furnish him with a Back-door to evade such an Answer. But tho' this be a little shocking at first, yet the Man who is truly knowing, will soon bring himself to confess, that there is such a Thing as an *Eruditum Nescire*, or a Learned Ignorance, *viz.* in such a one, who knowing at first what Great Men have pronounced about a certain Thing, yet can shew experimentally, that their Opinions are not to be received for Truth, and being himself asked about it, confesses his Ignorance without Reluctancy. This will by no means lessen the Esteem which he has acquired by his Learning in the Opinion of wise Men; and yet will produce this Fruit, that quite different from many unhappy Atheists, who fall into Error, thro' a Conceit of knowing all Things, he will acknowledge, that the Wisdom of GOD, as it shines out in the Phænomena of the World, does far surpass his own weak Understanding.

SECT. XIX. *The Use of Hypotheses.*

WE would not, however, that Men should believe from hence, that we reject all Hypotheses as quite unnecessary; since, if they be properly used, they are of great Service in many Cases; not only because they reduce the Thoughts of an Enquirer into a more regular Compass, and hinder them from rambling out too far; but chiefly, because they are of a particular Advantage in directing the Judgments of young People, and setting them a Pattern how they may afterwards Discourse and Argue from Experiments; provided it be done with such Prudence and Caution as may lead them to make a just Distinction between the one and the other: Wherefore, it is commendable enough in those Persons, whose Design and Duty requires them to direct Youth in the Course of their Studies.

SECT. XX. *A Third Inducement to Atheism, to admit of no Final Causes.*

I DO not know whether I should not lay down this for another Step or Inducement to *Atheism*, *viz.* the Maxim that some have taken up and maintained, *That in Philosophising, no Notice is to be taken of previous Designs or Final Causes.*

I do not here blame those Philosophers who affirm, that in the Study of Nature, where Men enquire how every thing *Is*, *Acts*, and *Moves*, the Contemplation of *Final Causes* have properly no Place; and I readily agree, that when one is asked, *How does such a Thing happen?* it is absurd to answer, *That it happens for such an End or Purpose.* But this is nevertheless true, that if such a Rule be admitted without any Restrictions, it may serve to mislead Men into a raw Conception, that all Things are made without a View or Design, and that *meer Chance*, or *unknown Causes*, take place in the World: Yea, the

Queſtion, *Why any thing happens*; or, *To what End it is ſerviceable?* ought not to be entirely baniſhed out of Philoſophy, as unworthy of great Underſtandings; tho' we ſhould allow, at the ſame time, that it does not properly belong to that Part of Phyſicks which contemplates the operating Cauſes; this, I believe, every Body will grant, who having enquired into Natural Things, has, with Pleaſure, ſeen the Uſes thereof, and the Service which they render both to the World, and to Men.

It is true, indeed, that in the Modern Philoſophy, this is not taught abſtractly from other Things; but as in *Pneumatics*, the Properties of Spirits; in *Phyſics*, thoſe of Bodies; in *Mechanics*, the Laws of Motion; in *Aſtronomy*, the Properties of the Heavenly Bodies; in *Optics*, thoſe of Light and Viſion are handled; ſo it occurs to me, and I think not without Reaſon, (if one ſhould treat expreſly about the Deſigns and wiſe Ends of the Creator, and ſhew the ſame from the State of Things, and from their Uſes) that a *Scopology*, or *Study of Ends*, would prove one of the moſt exalted Parts of Philoſophy, and might contribute, not only to convince many (who otherwiſe forget GOD) of their Obligations, and juſt Gratitude to their Great Maker; but likewiſe to render Famous to all Poſterity, ſuch as have been diligent and ſucceſsful in diſcovering new Uſes of Things, tho' the Things themſelves have been known long before. Thus we ſee, that *Harvey*, in the Diſcovery of the *Circulation* of the *Blood*, found out a Uſe that was never before known, of the *Heart*, *Veins*, and *Arteries*; ſo did *Malpighi*, of ſeveral of the Parts of *Animals* and *Plants*; ſo did *Borelli*, of the *Inſtruments* of *Motions*; whereby they have all of them render'd their Names honourable to future Generations.

SECT. XXI. *The Remedies againſt this wrong Notion.*

HOW much the Experimental Examination of the Creatures is uſeful to avoid the Evil Conſequences of ſuch raſh Principles, the nice and exact Enquirers in this Age have ſhewn us; eſpecially the Anatomiſts, who are wont, to all the Deſcriptions they have given us of Bodies, expreſly to ſubjoin the *Ends* and *Deſigns* for which they are ſo compoſed, together with their Uſes; and very often expatiate from thence, upon the Praiſes of the *Wiſdom* and *Goodneſs* of that *Being* which has formed them; of which the above-mention'd laudable Gentlemen, *Harvey*, *Malpighi*, *Borelli*, and a great Number more, are illuſtrious Examples.

SECT. XXII. *The Fourth Inducement is Diſputes.*

THE Fourth Inducement, which indeed does not of it ſelf always beget *Atheiſm*, but yet inſenſibly leads to it, and even hinders Men from being convinced of the moſt Fundamental and Divine Truths, is thoſe numerous Diſputes that are ſtarted concerning them, and of which there is never any End.

This need not be proved to thoſe that are acquainted with the Diviſions among the Ancient and Modern Philoſophers, who, tho' they join perhaps on all hands, to defend the Being and Attributes of a GOD againſt *Atheiſts*, yet do not agree in (but frequently reject) the Arguments brought by one another

to prove the ſame. By ſuch continual Differences, (eſpecially if Paſſion and ill Language be mix'd therewith) Men that are not ſettled in their Principles, are rendered yet more unſtable and doubting; and there is too great a Handle given to ſuch as deny a GOD, to maintain, with ſome kind of Probability, that all that has been ſaid and believed concerning Him, is not attended with ſo much Certainty as it ought.

SECT. XXIII. *Means to prevent the ſame.*

NOW to the end that we ſhould not be ſubject to thoſe Diſputes, and that a total Stop may be put to them, we ſhall here propoſe a Means, which we hope may ſeem proper for that purpoſe; which is ſeriouſly to ſet about enquiring, wherein the juſt Characteriſtick, or Mark, of the Truth or Falſity of a *Propoſition* or *Enunciation* conſiſts: For if People did but agree in this one Thing, they might, without any farther Cavilling or Diſputing, judge with Certainty of a Propoſition, in caſe it was accompanied with the right Marks of Truth, that it was True; and if it had the contrary Marks, they might pronounce it Falſe; and again, if thoſe Marks were obſcure on both Sides, they would declare it doubtful and uncertain.

But ſince it is more to be wiſhed than expected, that the Diſagreement among Philoſophers about the Characteriſticks of Truth, will ever be entirely laid aſide; the beſt way that I can think of to avoid, and put an end to Diſputes, is to make uſe of ſuch Proofs of the Truth or Falſity of a Propoſition, that have their Foundation not ſo much in Arguments, as in undeniable Experiments, as often as it can be done.

Men muſt be well confirmed in what has been here laid down, ſince we have a clear Proof thereof in our Modern Phyſicks; it being known to every one, at leaſt allowed by the moſt Learned, that in order to be aſſured of the Truth of a Poſition in this Science, the ſame muſt be demonſtrated by Experiments; and it has been found, that the greateſt Men of this Age, have allowed Experiments to be the only Characteriſticks of Truth, and that an end has been put by them to many Diſputes, and that very few new ones have ariſen in Natural Philoſophy, which have not thereby been quaſhed almoſt as ſoon as they appeared. Thus all the Debates, Whether the Blood circulates or not? Whether Water riſes in a Pump by the Preſſure of the Air, or not? Whether Nature can ſuffer a *Vacuum*, or empty Space or not? and a great many others, about which Men have ſo long wrangled, are now entirely removed by unanſwerable Experiments; and the Truth of the former, and conſequently the Falſity of the latter, are proved even by Ocular Demonſtration: And ſince the Motion or Reſt of the Sun, has not yet been determined by any Experimental Proofs the moſt famous Aſtronomers have yet made, that muſt be rank'd among thoſe Things that are to be accounted uncertain: But of this we ſhall treat more largely when we come to the Contemplation of *Unknown* or *Undiſcover'd Things*.

SECT.

Sect. XXIV. *The Abuſe of Academical Diſputes.*

Before I quit the Subject of Diſputes, I find my ſelf obliged to repreſent, with great Submiſſion to thoſe Gentlemen in whoſe Power it is to reform thoſe Abuſes, (in caſe this Book ſhould ever have the Honour to be peruſed by them) ſomething that may prevent the ſame; for tho' Diſputes may have been at firſt eſtabliſhed and made uſe of in ſome Univerſities with a good View, and for whetting the Underſtanding; yet they have given occaſion to many to cavil about the moſt weighty Truths; inſomuch, that you ſhall often hear them in publick Diſputes, arguing with as little Reſpect and Humility about the *Being of a God*, as concerning the vaineſt and moſt frivolous *Entia Rationis*, or Chimera's of the Brain; and you ſhall ſee them indifferently maintaining a *Theſis* of the *Great God of Heaven and Earth*, and immediately after diſcourſing of a *Vacuum*, or of *imaginary Space*; and without any diſtinction of Reverence in the one Caſe or in the other. This inſenſibly engages them in a ſad Cuſtom of vainly uſing the tremendous Name of God very frequently, and without the leaſt Devotion, and of making that moſt ſupreme and adoreable Being, which ought not to be thought of, much leſs named without Emotion, the Object of their wanton Speculations. What Evils this has been the occaſion of in ſome, is very obvious to thoſe who have experimented how much that Natural Contempt which they feel in their Hearts (without Reaſon indeed) for Divine Things, has been thereby increaſed.

I leave it to thoſe Gentlemen to whom the Superintendency over the Univerſities is intruſted, to find out Means, according to their great Wiſdom, for obviating theſe Abuſes; only, humbly offering it to their Conſideration, whether the Weight of this Great Affair does not loudly call for an Anſwer to the following Queſtions: *Firſt*, Whether it ſhould not be forbid henceforwards, that the Name and Attributes of the moſt *adoreable Deity*, ſhould be made uſe of only as Means for exerciſing young Underſtandings, and furniſhing Matters for Diſpute, with which *Philoſophy* does, beſides this, ſufficiently abound. *Secondly*, That thoſe Truths, concerning God and his Perfections in the *Metaphyſicks* and *Doctrine of Spirits*, wherewith Youth are to be inſtructed, be not any longer handled in Publick Diſputations, but in private Aſſemblies only, and (as it is the Cuſtom in *Divinity*) after having poured out a Prayer to God, with that becoming Humility and Reverence which is due to the Great Lord of all Things; the rather, becauſe moſt commonly young People only (who are of an Age in which the Judgments are moſt eaſily byaſs'd or corrupted, and the Paſſions do moſt prevail) are the Hearers of theſe Lectures and Diſputations. By ſuch Means we might begin to hope, that the Danger which ariſes from this diſreſpectful manner of Diſputing, may be hinder'd from taking Root in young Minds; and that every body might be convinced by the pious Examples of the Academical Teachers, and reverend handling of theſe Matters, that Learned Men do likewiſe fear God; the contrary to which is maintain'd by many *Atheiſts*, and is one Method whereby they ſtifle the Remorſes of their own Conſcience.

Sect.

SECT. XXV. *The Fifth Inducement, Inattention or Heedleſneſs.*

BESIDES what has been already ſaid, there is ſtill ſomething more, which indeed does not carry Men into compleat *Atheiſm*, and yet does very much contribute to hinder them from diſcovering GOD in his Works; inſomuch, that many People do, upon that Account, paſs their Lives without obſerving, at leaſt without being convinced, of theſe weighty Matters; and that is a *Natural Sloth and Careleſneſs, or want of conſidering with proper Attention, thoſe Things in which the Perfections of the Creator ſhine out ſo brightly.* We are all deſirous to ſatisfy our Curioſity, and therefore we earneſtly contemplate, and oftentimes enquire into the Cauſes of all thoſe Things which we take for Wonders; becauſe the Manner in which they happen is unknown to us. If Comets or *Parhelia* appear, if the Sun or Moon happen to be eclipſed, how eagerly are they obſerved both by Learned and Unlearned Men; and yet we daily ſee the Sun riſe, and the Moon and Stars ſhewing themſelves; the Earth and Trees cover'd with Flowers and Fruits; Humane Creatures and Beaſts procreating, and a thouſand other Wonders, and remain very indifferent towards them all, without dwelling long enough upon the ſame, and obſerving them with that Care and Judgment we ought, or turning our Thoughts towards the firſt Cauſe and Author of all.

Methinks one might conclude, that the frequently repeated View of ſuch Things, each of which alone are wonderful in themſelves, ſhould make ſo much the ſtronger Impreſſion upon our Minds; and yet moſt commonly we experience the contrary. That this ſhould obtain in ignorant People, is not ſo ſtrange; but it is much to be lamented, that ſuch a *Heedleſneſs* ſhould many times be found in thoſe who do not want for good Underſtanding, and who are deſirous to paſs for Philoſophers. One might likewiſe allow it in ſuch as are not much accuſtomed to value or ſhew any reſpect for the Knowledge of a GOD, or the true Cauſe of all Things; but that others ſhould be ſo careleſs in this Matter, who are ſo well convinced of the Importance of this Enquiry, that it does not ſuffer them to be ſilent, but upon the leaſt occaſion do continually argue for it, (inſomuch that I have not been able to diſcover the Doubts in which they were, or had been) is a Thing that muſt needs appear unaccountable to every Body.

The Reader will not diſpute the Truth of what I have here advanced, when I tell him, that I have been perſonally acquainted with ſome Men, who were formerly thus heedleſs, and altogether inſenſible of the Works of the Great Creator; but being afterwards brought to a more due Attention, were aſtoniſhed at themſelves, that thoſe very Things which a Wiſe Maker and Powerful Ruler did, as it were, cauſe them to feel with their Hands, which had been known to them ſo long before, which they had frequently meditated upon in their Studies, which they had read in the Works of other Men, and had often diſcourſed of them with others, ſhould not have carried their Thoughts up to GOD, nor cauſed them to feel in themſelves the leaſt Conviction of his Being.

If Cuſtom be the occaſion thereof, which, becauſe we daily ſee ſo many Wonders, makes us receive them without any Impreſſion; one can only ſay, that it is by ſuch a Cuſtom we become quite Blind, and wholly Inſenſible.

Sect. XXVI. *Means to prevent ſuch Inattention.*

The only Natural Means that I ever found effectual to render us more attentive to every Thing, is frequently to apply our ſelves to new Diſcoveries and Experiments, which appearing to us upon every Eſſay, to be New and Uncommon, do give us an occaſion of obſerving with Aſtoniſhment the *Wiſdom*, *Power* and *Goodneſs* of Him that Orders all Things after ſuch a manner; eſpecially, if we endeavour to wean our ſelves (which is here abſolutely neceſſary) from this our Natural Sloth, and continually join our Experiments with theſe Obſervations.

This is not the Place to take notice of another and true Cauſe of our Blindneſs, which, in this reſpect, is ſo great as to hinder us from ſeeing the Perfections of God in the Works of the Creation, tho' they be daily before our Eyes; to wit, *the univerſal Corruption of Mankind*; becauſe this is only to be remedied by Prayers, and by the Grace of God it ſelf; but no ways by natural Means, which is what we are here chiefly concerned about.

Sect. XXVII. *Why we only make uſe of Proofs drawn from Natural Philoſophy.*

From all that has been already ſaid, it may be inferr'd, that the exact and experimental Obſervations of what we ſee in the World, is a demonſtrative Means, not only to obviate ſo many Cauſes and Inducements to *Atheiſm*, but likewiſe to attain to the Knowledge of a God and his Perfections by his Works; and let no Man think it ſtrange, that in the following Diſcourſes I make uſe of this Method, and not of other kind of Arguments, which are commonly called *Metaphyſical*.

The Reaſons that led me thereto are theſe:

Firſt, Becauſe many learned Perſons have unanſwerably confuted the *Atheiſts* after a *Metaphyſical* Manner, that is, ſuch a one as is built upon Reaſoning: The Proofs therefore, of this Kind, may be found in great abundance in their Writings.

Secondly, Becauſe Experience and Converſation with ſome of theſe unhappy Philoſophers, has taught me, that the Contemplations of God's Works, when one could bring 'em thereto, has induced ſome among them to alter their Sentiments, who for many Years had withſtood other Proofs; becauſe the Subtleneſs of their Underſtanding ſeemed to furniſh them always with a Handle to diſpute againſt *Metaphyſical* Arguments, and ſo left them ſtill diſſatisfied.

SECT. XXVIII. *Because GOD is pleased to make use of this Way in his Holy Word.*

THE Word of GOD does likewise give Testimony to this same Method in many Places of it: Thus we see St. *Paul* makes use of the Creatures for a Demonstration of GOD's Eternal Existence; Rom. i. 20. *The invisible Things of him, from the Creation of the World, are clearly seen, being understood by the Things that are made, even his Eternal Power and Godhead.*

In the same Manner *David* relating the Works of GOD in a most sublime and pathetical Strain, in several Verses of the 104th *Psalm*, proves from thence his great Wisdom, ver. 24. *O Lord, how manifold are thy Works! in Wisdom hast thou made them all.*

Thus the GOD of Heaven does not command us to seek for Arguments from the Depths of Philosophy, in order to see his Power, but only to turn our Eyes towards his Works; *Isaiah* xl. 26. *Lift up your Eyes on high, and behold who hath created these Things, that bringeth out their Host by Number; he calleth them all by Names, by the Greatness of his Might, for that he is strong in Power, not one faileth.*

His Mercies are also shewn from his Actions in the 107th *Psalm.* We likewise see the Almighty himself in the Book of *Job*, Chap. xxxviii, xxxix, xl, & xli. making use of Proofs taken only from his Works, exhorting us, in many Places of his Holy Word, after the most earnest Manner, thus to contemplate his Perfections in his Works. Thus we hear the Holy Ghost, in the 107th *Psal.* ver 43. after having given a circumstantial Relation of the Actions of GOD, finally making this Conclusion: *Who is wise, and will observe those things? Even they shall understand the Loving-kindness of the Lord.*

From whence it plainly appears, that towards such wise Understanding, no feigned Hypotheses, but an Observation of Things themselves, which can only be made by Experiments, is required; for which Reason Men are wont even to this Time to bestow the *Latin* Term of *Observations* upon what we find out by Experience.

And so great a Stress is laid upon this Exhortation of knowing GOD by his Works, that those who do not study them after that Manner, are pronounced Foolish, and void of Understanding; Psal. xcii. 5, 6. *O Lord, how great are thy Works? and thy Thoughts are very deep: a brutish Man knoweth not, neither doth a Fool understand this*; for which Reason, the not enquiring into the same, is by the Spirit of GOD reckon'd among the Causes of *Atheism*; Psal. x. 4. *The Wicked, thro' the Pride of his Countenance, will not seek after God: God is not in all his Thoughts.*

SECT. XXIX. *The General Proof or Demonstration of a GOD.*

AFTER having fully comprehended all the foregoing, we might now have proceeded to the Contemplations of the World, and the Perfections of GOD, in the Composition, Parts and Motions thereof, were it not that what follows may yet seem to require, that we should previously shew after what Manner, from the visible World, and that which we see pass therein, a Proof

may

may be formed upon, which we may rely and be assured, *First*, That there is a God, that is to say, a Wise, Powerful and Gracious Maker and Director of all Things; And, *Secondly*, That the Bible (his revealed Word) is of a Supernatural and Divine Origin.

As to the Manner of Demonstrating the First, I shall, without entering into deep Speculations, like some Philosophers, seriously entreat every one, that with a composed Mind, and divesting himself of his Passions and Prejudices, he would silently set down, and seriously consider, *First*, in case he should see that,

1. Not one, but a great many,
2. And various or different,
3. Things entirely ignorant, or unknowing of all, and even of themselves too:
4. Each of them frequently, after a particular Manner,
5. However always unchangeably, and observing the same Rule;
6. Do act and move not once, but upon many Occasions and Times;
7. And not one of all them able to impart such *Motion* to it self;
8. Not unless they thus come together of themselves, can produce one single Effect without their own Knowledge:
9. In the Production of which Effect or Thing, if some few Circumstances only, or oftentimes but one single one were wanting, it could not either be produced at all, or at least not in its due Perfection:
10. Altho' that same Effect should in it self be of great Use and Service, and sometimes of the utmost Importance:

Could he imagine otherwise, than that all these things are formed to that End, and brought together with that Design, to work such an Effect as we observe to be produced by them?

And, *Secondly*,

Supposing this first to be true, since these things are in themselves ignorant and unknowing of all that passes; whether every Body must not agree, that they are all produced, and made to concur by a wise and understanding Agent, who had such an End and Design in his View? And whether any one can perswade himself, that meer Chance, and unknowing Laws of Nature, or other Causes ignorantly co-operating, could have Place herein, and could have directed and governed these Things in all their Circumstances and Motions for such a Purpose?

That this may be shewn after a more plain and not less certain Manner, let us apply to some particular Thing what has been just now advanced in general, and as it were in an abstracted Manner; and let us suppose, that in the middle of a sandy Down, or in a Desart and solitary Place, where few People are used to pass, any one should find a Watch, shewing the Hours, Minutes, and Days of the Months, and having examined the same, should perceive so many different Wheels, nicely adapted by their Teeth to each other, and that one of them could not move without moving the rest of the whole Machine; and should farther observe, that those Wheels are made of *Brass*, in order to keep them from Rust; that the Spring is of *Steel*, no other

Metal being ſo proper for that Purpoſe; that over the Hand there is placed a clear Glaſs; in the Space of which, if there were any other but a tranſparent Matter, he muſt be at the Pains of opening it every time to look upon the Hand: Beſides all which, he might diſcover in it a Hole, and exactly oppoſite thereto a little ſquare Pin: He would likewiſe ſee hanging to this ſame Watch a little Key compoſed of two Pieces, making a right Angle together; at the End of each of which there was a ſquare Hole ſo order'd, that one of them was exactly adapted to the little Pin in the ſaid Hole, which being applied thereto, a Chain would be wound up, and a Spring bent, by which Means the Machine would be continued in Motion, which otherwiſe would be in an entire Reſt: He might alſo find, that the other ſquare Cavity, at the End of the little Key, was adapted to another Pin or Inſtrument, which being turned this Way or that, makes the Hand move faſter or ſlower. At the other End of this little Key there would be a flat Handle, which being moveable therein, might give him the Conveniency, that in the Winding it up, he ſhould not be obliged to take hold of it at every Turn of his Fingers.

Laſtly, He would perceive, that if there were any Defect either in the Wheels, Spring, or any other Parts of the Watch; or if they had been put together after any other Manner, the whole Watch would have been entirely uſeleſs.

Now the Queſtion is, in order to form a Kind of Demonſtration from hence, *Firſt*, Whether any Body can imagine, that ſuch a Watch among other Purpoſes, to which it might perhaps be ſerviceable, was not likewiſe made for this End, that it ſhould ſhew the Hours, Minutes, and Day of the Month. *Secondly*, Whether he ſhould make the leaſt Scruple to admit it for a Truth, that ſuch a Machine was made and put together by an underſtanding Artificer for this very Purpoſe, who, when he made it himſelf, knew that, and to what End he had made it.

And, *Thirdly*, Whether it be poſſible that he can perſwade himſelf that this Watch, with all belonging to it, the Niceneſs of its Makes, Figure of ſo many Parts, and other Contrivances for ſhewing the Time, could have acquired its Being and Form by meer Chance only, which operated indifferently one way or another, and without any certain Rule or Direction?

Or otherwiſe, whether he could expect to paſs for a Man of Senſe and Underſtanding, if having found this Watch in a ſolitary Place, he ſhould pretend to believe that it was not made by a skilful Workman, nor that its Parts were put together with Judgment; but that there was a certain ignorant, and yet neceſſary Law of Nature prevailing in the World, that had brought into a regular Method all the Parts of which this Watch conſiſted, and had adapted each of them to the Uſe of ſhewing the Time of the Day; and eſpecially, that ſuch a Law of Nature was not only ignorant and unſenſible of all that it did, or brought to paſs, but likewiſe, that no Being, endued with any Wiſdom or Underſtanding, had eſtabliſhed and produced this Law at the Beginning, or in the leaſt contributed to the making the ſeveral Parts that compoſed a Machine proper to ſhew the Hours.

What has been ſaid above concerning a *Watch*, is not leſs applicable to all other artificial Works; it will be therefore unneceſſary to alledge any farther Examples of *Mills*, *Ships*, *Sluices*, *Houſes*, *Paintings*, &c. In all which, the Wiſdom and Underſtanding of the Maker does equally appear.

Finally, We may apply all that has been ſaid above to demonſtrate, that there is ſuch a Wiſe, Mighty, and Merciful Being as GOD, in caſe we can make appear with as great (not to ſay a much greater) Certainty and Conviction, from the Conſtruction of the viſible World, and all that paſſes therein, that there is a GOD and Great Creator, who in Wiſdom has made them all; as we can ſhew from the Structure of a Watch, and the Uſes that reſult from the ſame, that it has been made and put together by a judicious and skilful Workman; and this we doubt not of doing in the following Contemplations, with all neceſſary Clearneſs.

SECT. XXX. *A particular Manner of Corroborating theſe Proofs in ſome other Circumſtances.*

WE ſhall not here enumerate other Kinds of Proofs, to ſhew the Defect of the Principles of theſe miſerable Cavillers, which we have made uſe of upon ſome particular Occaſions in this following Work, becauſe we will not make this *Preface* too long. They that find them in ſome Places, are deſired to apply them to others where they think them to be of equal Force; though, for Brevity ſake, we may have there omitted them.

As for Inſtance, in caſe the Reader be not ſufficiently affected or convinced by what is ſaid of Living Creatures, Plants, Heavenly Bodies, and ſuch like, let him imagine to himſelf that he ſaw the ſame Things imitated in little; and that tho' they be incomparably more imperfect, yet they do in ſome manner counterfeit the Works of Nature. To ſpeak more plainly, let him fancy that he ſees a Wooden-Horſe put into a Motion by Springs and Wheels, a Wooden-Bird flying (of which Hiſtory has made mention) or let him ſuppoſe that he ſees in a little Machine, a gilded Globe, repreſenting the Sun, and other little Balls, which like Planets circulate about it; and then let him ask himſelf, whether he has Boldneſs enough to maintain, in the Preſence of Wiſe and Learned Men, that all theſe Things appear to him to be produced by *meer Chance*, or by certain *unknowing natural Laws?* And whether he has not a great deal of Reaſon to believe, that ſuch Sentiments would be juſtly laughed at, even by the Ignorant themſelves? And after all, let him conſider with how much leſs Reaſon he entertains ſuch Opinions, entirely different from thoſe of all wiſe Men, concerning the true, natural, and unconceivably more perfect Things, which daily occur to his own, and all other Mens Obſervation in the World.

SECT. XXXI. *A General Proof, that the Scriptures are of a Divine Original.*

THE ſecond Thing that is here neceſſary to be enquired into, before we paſs on to the *Contemplations of the World*, is a certain Manner of proving (which we ſhall upon ſome Occaſions hereafter inſiſt on) that the *Bible*, as

it is call'd by *Chriſtians*, was writ by a certain Great and more than Humane Wiſdom, and that it is of Divine Authority and Original.

To ſpeak a Word or two of it here in general, I entreat my Reader ſeriouſly and carefully to conſider,

In caſe he ſhould meet with a Book, which for weighty Reaſons was held to be Divine by other People, among whom there were a great many that he allowed to be very underſtanding Perſons; and ſuppoſing, that whilſt he read and examined it, he ſhould find,

Firſt, That this Book did frequently make mention of certain Qualities of Natural Things (tho' with another View, and as it were *en paſſant*) after ſuch a Manner, as none but an Eminent, Wiſe, and Experienced Naturaliſt could do; Whether he would not be obliged to conclude, with reſpect to that only, that ſuch a Book muſt have been writ with ſingular Wiſdom?

Secondly, Suppoſe he ſhould be farther convinc'd, by irrefragable Proofs, that this Book did repreſent, with the cleareſt Words, certain Properties of Natural Things; which at the ſame Time it was writ (at leaſt ſo far as can appear to us) were not known to any living Perſon, nor for want of the neceſſary Inſtruments could poſſibly be known to any, whether it were to be doubted, that ſuch a Book were writ with more than Humane Wiſdom?

And this being granted, from whom can we more reaſonably conceive it to be derived, than from the Omniſcient Creator of all Things? To whom alone, the Things that were hid from every one elſe in thoſe Ages, were known and open.

And in caſe you deſire to have this laſt proved more ſtrongly, we may ſubjoin, *Thirdly*, That in ſome Places of this Book is expreſs mention made of the Bounds and Limits of Humane Knowledge in future Things; the Truth of which could not appear, but to the following Generations.

This being ſo, as it ſhall be proved hereafter, Can any but a Divine Power determine and limit, by clear and plain Expreſſions, that certain Things ſhall come to paſs after many Ages? And when they have ſo happened, muſt not every one acknowledge, that it could proceed from no other than a Divine Original?

SECT. XXXII. *No Proofs can be brought of the Divinity of the* Alcoran *of the* Mahometans.

WHAT has been here ſaid concerning the wonderful Wiſdom that ſo brightly appears in the Holy Scriptures, might truely be urged upon many Occaſions againſt the *Alcoran* of the *Mahometans*, where we ſhould in vain ſeek for an Account of the Conſtruction of the World, of which ſo much appears in the Bible of the *Chriſtians*; but ſince theſe Papers are not ſo much calculated for the Conviction of *Mahometans* as of *Atheiſts* and *Unbelievers* in general, it ſeems to me ſufficient, juſt to touch upon it here, without repeating it upon every Occaſion in the following Diſcourſes.

SECT.

SECT. XXXIII. *A short Account of what is proposed to be done in the following Work.*

NOw that we may reduce all that has been said to its *End* and *Design*, and that we may convince every reasonable Person of the Perfections of GOD, this alone chiefly remains;

First, That we endeavour to shew, that in the visible World, or rather in that little of it that is as yet thorowly known to us by Experience, there does appear so much Wisdom, so much Power, so much Goodness and wonderful Views, that the greatest Work of Art that ever was prepared by Men, is not comparable to it in the least.

And, *secondly*, that we endeavour, by convincing Examples, to show the undeniable Truth of what has been said above, relating to the Holy Scriptures.

We know very well that an *Atheist* may, upon some Occasions, object against this last; that, *perhaps*, at the Time when the *Bible* was writ, *Telescopes* and *Microscopes* were in use, and, *possibly*, brought to as great, if not greater Perfection than we find them in this present Age; by which Means they will endeavour to evade the Proof which we, in some Places, have urged from the late Discoveries thereof: But to answer them in one Word, let them consider with themselves,

First, That altho' we have Astronomical Observations of many Ages past, and with them the Descriptions of several Instruments then used; yet we do not find any mention made of *Telescopes*, nor so much as the Name of *Microscopes* among any of the ancient Enquirers into Nature.

Secondly, That the Inventors of these two Instruments, who lived in the foregoing Age, were known to all the Philosophers; no body being yet able to prove from any Memorials, that they were known to others before.

Thirdly, Whether it be credible, that the old *Astronomers* or *Naturalists*, if they had known the Things that have been since discover'd by these *Optical* Instruments, would have transmitted down to Posterity their defective, and, many times, false Conceptions of Things.

Finally, And which is of the greatest Importance, let them seriously consider, how prudent it is, in a Matter upon which their everlasting Welfare or Misery depends, to support their Sentiments with a *perhaps*, *or it may be*, when, besides, every Thing that appears in History makes against 'em.

The Religious Philosopher:

OR, THE

Right Use of the Contemplation of the World,

FOR THE

Conviction of Atheists and Infidels.

CONTEMPLATION I.

Of the Vanity of all worldly Things.

SECT. I. *Every Man is placed here without his own Concurrence.*

TO begin therefore by convincing not only those who are still under Doubts, (whether they be to be reckoned among the External Christians or not) but even the deplorable and obstinate Atheist, of the great Necessity there is to be rightly assured of the most important Truths, and to correct those Mistakes which he has hitherto admitted concerning every one of 'em, is entreated most seriously to reflect upon the Things which his own Experience informs him daily to come to pass about him, and to ask his own Conscience, whether he don't find himself placed in this World without any Act or Concurrence on his own Part? Whether it be in his Power to prevent his being one while Happy, Healthy and Strong; another while Unhappy, Sick and in Pain? Whether one Day

Day does not follow another without his Leave, in which divers things befal him, some with, others against his Mind, notwithstanding that he feels in himself a continual Desire influencing and governing all his Endeavours of obtaining Good, and avoiding Evil; which sometimes succeeds, and at other times happens quite otherwise than he hoped for or intended, by Accidents which he could not escape?

Whether he does not observe, that what befalls him is in common with other Men? But chiefly, Whether he does not see that many Men die daily, and that very few of them seem to have any Thoughts concerning Death, especially whilst they are in Health? Notwithstanding that Sickness and Diseases, by which they are snatched away, oftentimes stand in need of but few Weeks, sometimes few Days, yea even Hours, to change them from strong and healthy Men into dead Bodies or Carcasses.

SECT. II. *And must be convinced of the Uncertainty of his Life.*

FURTHER, whether he is not like all other Men, ignorant of the Time when Death shall overtake him? Yea, at the End of one Year he sees a great many, who in the Beginning of the same, were alive and healthy (and some of whom seemed to be stronger than himself) to be singled, as it were with Design, out of the great Number of Mankind, and to be a Sacrifice to Death and the Grave; and that no Body has been able hitherto to find out any Rule or Law whereby he could conclude, that this or that Man should die first; unless perhaps some very old or incurable Persons, of whom indeed he might say, that their Death was not far off: But even in such case, 'tis not less true that he is ignorant, as near as they may seem to be to their End, whether he himself shall not go before them; so that every Man is forced to own, that his End may be near, as well as that of those whom he sees die before him; and who, whilst they were in Health, knew as little thereof as he himself does now of his own Death.

SECT. III. *He must likewise be convinced of the Vanity of all worldly Things with respect to himself.*

NOW since Death does so surely overtake every Man, and yet the Time of it is so uncertain; since it deprives us of the Use and Enjoyment of all that is in the World, ought not every one that considers these Matters be convinced of the great Vanity that is in himself, and in all worldly Things with respect to him? Forasmuch as he cannot enjoy either Profit or Pleasure from thence, but so long as he lives; and how long, or how short that Life will last, he knows not. This only he knows, that when he is arrived to a certain Number of Years, it cannot be very long: And he cannot say, if he considers every Thing as he ought, that it is very desirable to attain to a great Age; since being deprived of the Use of all his Faculties, his Death is as it were anticipated thereby; for it leaves him neither Feet to walk, Eyes to see, Ears to hear, or Teeth to eat with; and thus, while he is still alive, he is by degrees thrust out of the Company of Men, and becomes, as one may say, a living Carcass.

SECT.

SECT. IV. *It is not even desirable to live here continually, tho' in Health.*

NOW if we should add to all this, that such as live long are not only subject to the Infirmities of old Age, but often to very grievous Sickness and Pains, some of which are entirely or almost incurable, *viz.* in case he be deprived of all his Strength, and worn away by a Consumption, or tormented by the Gout, or Stone in the Bladder, by a cancerous Humour, or by the Falling-Sickness, to say nothing of a thousand other Distempers to which he is obnoxious, and which he may justly apprehend, because he sees so many other Men affected with 'em: Would not he have a great deal of Reason to wish that merciful Death might set him free from all these, and from miserable old Age at the same Time?

Now if one should suppose, which however scarce happens to any Man, that the Evils of old Age do not render his Life a Burden, and that he shall enjoy even as long as the World it self shall last, the same Strength both of Body and Mind as he did in his Youth; yet when he seriously considers every Thing, this very State and Condition, far from being desirable, must appear to him very deplorable: For, *First*, in case his Native Country should be ruined and laid waste by Earthquakes, Inundations, or War, he cannot escape Misery and Poverty as well as the rest: And how many Years of tedious Labour are there required to repair what he has lost, so as to be able to enjoy the same the remaining Part of his Life? And having scraped it up again with Trouble, must not this Man, who is to live as long as the World stands, be always in Pain and Fear of losing it, either after the same, or some other Manner? At least, since the World it self is subject to those Revolutions with which the Histories of all Ages have acquainted us. How few Governments are there that have been able to keep their Footing for several Ages together, and of which the Inhabitants have not been driven or rooted out? And on the contrary, how many can we reckon, which after they have risen to the highest degree of Glory and Grandeur, yet at last have found their End in an entire Destruction? So that even such a long and healthy Life, as we have been supposing, would only be a miserable Pilgrimage for him, in which, when he had hardly come out of one calamitous State, he would be in a continual Apprehension of another.

And if no evil Accident should overtake him (which is not to be conceived) what Pleasures are there in the World that are lasting? So that he can expect nothing else, but that such a Pleasure, which whilst it was new, was very agreeable to him, either by long Enjoyment (as Custom renders all Things) would become first indifferent, and afterwards insipid; or at best, by the Uncertainty which is visible in all Things, would soon forsake him: Had he a Wife, Children, and good Friends, which are the most comfortable Things of this World, they would all die before him; and he would every time be subject to that heart-breaking Sorrow, of losing those dearest Treasures, were they to live long? So soon as they are overtaken by the Infirmities of old Age, they would only be continual Objects of Pity, and consequently of Grief to him: Yea, every Thirty, Forty, or at least

Fifty Years, he would meet with a new, and consequently a strange Generation, and be obliged at every Turn to enter into new Friendships and a new Acquaintance; or to converse with unknown People, whose Inclinations he must study and learn to know again, to the End that he may, whether he will or no, conform his own to theirs, if he expects to enjoy any Favour or Kindness among them, and not to be excluded from their Conversation as a stiff and ill-natur'd Fellow: And if he has had Children, of which even a numerous Posterity are remaining, what Friendship and Love can he promise himself from them? Who, tho' they were descended from him, would be yet in a remote Degree of Relation; since Experience teaches us, how soon all Kindred, after a few Descents, grow strange to one another: And I have often thought, if *Adam* himself, our common Father, should return again to the World, and stay here some Ages, whether any of his Posterity would receive him friendly? Especially if he should pretend to make use of that Right, by which he alone would be entitled to, the Property and Government of every thing: Would not the most Part, if not every individual Man, think that he did them Wrong, and see him, with Concern, taking Possession of their Habitations? Now in case the Respect and Love which every one owes him, could not so far prevail, as to render a Father happy among his Posterity, what could be expected by a Man in so great, tho' strong and healthy old Age, who would be no longer considered as a Father, but as a remote Kinsman, whose Pedigree could not be traced, or perhaps even as a meer Stranger?

Sect. V. *The miserable Condition of the Atheists.*

Since then a long and healthy Life, which otherwise seems to be the most desirable Blessing upon Earth, is so vain, a Man cannot be render'd happy thereby; let any one who doubts or denies the Perfections of a God, extend his Thoughts farther; and see, *First*, how dreadful such a Life would be to him in particular, even tho' according to his miserable Philosophy, he had no God to fear, and that all Things were directed either by meer Chance, or by irrational, unknowing, and necessary Causes.

For from such Principles as these, he must grant, that in case he were unhappy, nothing but Chance could relieve him; if he were happy, since the Cause thereof is accidental and ignorant of its own Effects, he must live in a continual Fear, that every Moment may change his Condition: And not to reckon up all the Circumstances that may evince the same, what is there in the World from which he can expect the least Happiness or Advantage with any Foundation of a reasonable Hope, and from whence he can expect any Love or Good-will towards him, let him behave himself as he will? And that Man's Life must be very miserable, who is neither Loved nor Esteemed by any Body. Suppose he were a Prince that Governs a whole Nation, how can he think, without great Uneasiness, that it is by meer Chance his Subjects obey him? If he be subject, and lives under the Command of a Superior, must he not tremble when he considers that it is Accidental only that his Goods are not stolen; his Houses burnt; his Wife and

Daughters Ravished; his Sons carried into Slavery or Murdered; and that it is by meer Accident that his Children, being Wicked, do not, without any scruple of Conscience, Poison him for the Sake of his Inheritance, in case they think he keeps them too long out of it? And since upon this same Hypothesis there is no kind of Order or Providence, and that Chance, as Chance, may at all times produce, indifferently, this or that Effect; Must he not tremble when he looks upon the Earth, which, if every Thing depends upon Chance, may immediately begin to burn under him, or may open her Mouth and swallow him up? And if he looks into the Air, must he not imagine, that it is purely Accidental that he is not destroyed by Storms and Tempests, by Thunder and Lightning, or that Rains and unseasonable Weather do not ruin all his Plantations and Possessions?

In vain, also, will he endeavour with such like Conceits to avoid all these Terrors; though he should admit that it was not a meer Chance, but an unintelligent Necessity which Governs the Universe by certain unchangeable Laws; for since according to these supposed Laws, he sees several interfering Operations of Nature come to pass, whilst he sees the Air one time Calm, another time Tempestuous; whilst he sees the Wind from the South, and then again from the North; the Sea Ebbing and Flowing; one Season extreamly Hot, another very Cold, and the like; must he not confess (tho' he should suppose that all this did necessarily happen) that it will be as terrible to him as Chance it self; to him who knows not when a contrary Effect shall be produced according to these same Laws.

SECT. VI. *The Advantages which they that Love and Fear a God enjoy.*

LASTLY, Let him tell us sincerely, whether in respect to all that has been said, he does not think those Persons to be unspeakably more happy, who are convinced that they depend upon an adorable Creator; by whose Wisdom they have been so wonderfully formed; whose Power has render'd so many of his Creatures subservient to their Well-being; who has given them the Capacity to enjoy the same with Pleasure and Thankfulness; who being Wise and Mighty, can preserve them, and being Merciful, will preserve them; that without his good Pleasure, none of the aforesaid Evils come upon them; insomuch, that if He be with them, nothing can be against them; who, besides the good Things of Nature which He is largely and constantly dealing out to them, makes known his Word to them; and to remove all their Doubts, has stamp'd it with irrefragable Marks of its Divine Original; who has there revealed His Will, pursuant to which He will be sought after, served, thanked, and praised by them; who has there manifested his Love to them, which passes all Understanding; and has likewise promised to render them eternally happy after Death.

SECT. VII. *It is therefore necessary to seek for the Demonstrations of a God,* Psalm xiv. 1.

NOw since every Atheist must confess, that his own Principles (unless he will deny them too) do render him unhappy, and cause him to live in

continual Apprehensions; I leave him to judge, whether a Man must not be a very absurd Person, and, as it were, an Enemy to himself, who notwithstanding that he sees the contrary Opinion maintain'd by many others, of whose Wisdom he has no Reason to doubt, yet takes all the Pains imaginable to perswade himself that there is no GOD; and therefore, whether the *Holy Penman* of the first Verse of the 14th *Psalm*, has not a great deal of Reason to give such a Man the Name of *Fool?* who tho' he can never prove his Opinions, yet with all his Heart, and all his Soul, endeavours to make himself Miserable, and to run headlong into a State full of Terror and Distraction; that is to say, into the Condition of an *Atheist.*

For a Confirmation of the Truth of what has been here said, I could farther add, that I my self have heard one of these miserable Wretches, whose Judgment seemed capable of every Thing but acknowledging a GOD, lament the Unhappiness of his Condition with great frankness, and in the most pathetick Manner.

And I can't forbear saying, that the Remembrance of it does still very much affect me whilst I am now writing it, tho' long after his Decease.

To proceed; If any one has a true Love for himself, and does but hear that it is maintained by many Persons for an uncontroverted Truth, that there is a *Wise*, *Mighty*, and *Merciful* Creator of the Universe, who can render all those that endeavour to know, serve, and honour Him, Happy both now and for ever; and those that deny or despise Him, Miserable to all Eternity: I say, that Man must be in a very desperate Mind, if he does not think it to be of the utmost Importance to enquire into the Force of such a Proof, upon which so many wise Men, living and dying, do entirely depend.

SECT. VIII. *The Transition to the following Contemplations.*

I HOPE then, that among these unhappy Men there may be some found, who, in order to free themselves from these sad Uncertainties (for no *Atheist* ever had any Certainty of his wretched Notions) will think it worth their Pains, seriously to weigh the Arguments that may contribute thereto; and we beseech such to pass on along with us to the following Contemplations; and perhaps the Great GOD of Heaven and Earth may vouchsafe (as we heartily beg of Him for their Sakes) to open their Eyes, to the End that they may see, and be fully convinced of the unexpressible amiable Perfections of his glorious Works.

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CONTEMPLATION II.

Of all that is Visible, and of Our selves in particular.

SECT. I. *It is necessary to call upon GOD at the Beginning.*

BEFORE we come to the Thing it self, and from the visible Part of the World endeavour to shew, that in the Structure thereof, the Wisdom, Power and Goodness of the Great Creator shines out with more Brightness and Lustre, than to admit of a Comparison between any of his Works and those of the most skilful Artificer that ever was: Let it not seem strange to any one, that in this Enquiry, which perhaps may be thought purely Natural, we affirm it to be absolutely Necessary, first of all to implore the Great Creator and Governor of all Things, with the deepest Humility, that He would be pleased to enlighten our Understanding (which in it self is so dim) that we may view and comprehend the Beauties and Wonders of his Works; and farther, that thro' his Goodness, He would vouchsafe to purify our Hearts from all contradicting Passions and unreasonable Notions resulting from thence; since it is not unknown to any one who has obtained this Grace, that He can, as it were, feel and discover, in innumerable Things, with an entire Conviction of his Conscience, the adoreable Maker of them; that many Things have often presented themselves to his Mind formerly, and have been rightly understood and comprehended by him, without once exciting him to look up to the first and chief Cause thereof: So that it plainly appears from hence, that neither the Peneration of his Judgment, nor the Things themselves, are sufficient to lead him to a right Contemplation, without some farther Assistance besides them. And in case an Atheist should only consider these Convictions as Historical Truths, yet at least he must acknowledge, that in a Matter of so great Importance, and upon which his everlasting Happiness or Misery depends, it would do him no Harm, according to his own Principles, if, like the *Athenians*, he should invoke the Assistance of a *GOD*, as yet *unknown* to him.

SECT. II. *GOD's Eternal Existence proved from the Creatures.*

NOW to proceed to our intended Work: Since our Design is rather to Offer or Propose the Proofs of the Perfections of GOD, that is to say, of his *Wisdom*, *Power*, and *Goodness*, by way of Conviction to unhappy *Atheists*, and doubting Minds, than to prove his *Eternal Existence*, that being not denied by any *Atheists* who own an *Eternal Being*, as far as I know; yet if there be any among them so blind, as still to doubt whether this also can be demonstrated

strated from his Works, we shall likewise endeavour to give them full Satisfaction herein, and to produce unanswerable Proofs thereof in this very Place, before we proceed to the other.

Let the *Atheist* then ask himself, upon the Supposition that there was no Eternal Being, that is, in case there ever was a compleat *Nothing*, when there was neither Creator nor Creature, nor any thing whatever that had an Existence, whether he must not be convinced, that in all Eternity the smallest Thing whatever could not come to Exist; and that such a *Nothing* must remain and continue to infinite Ages a meer and simple *Nothing?*

So that not only from these vastly extended Heavens, and their unspeakable great Lights and Bodies, but even from the most tender Leaf or Grass, from the most contemptible Stone we tread upon, and from the smallest Grain of Sand, this Assertion can be irrefragably maintained; since if ever there was a compleat *Nothing*, the very meanest of all these could never have been produced, or made to Exist in an Infinity of Ages.

Sect. III. *The same proved from* Romans i. 20.

After the same Manner we see the Apostle *Paul* proving God's *Eternal Power*, whereby He Exists of himself from all Ages, and his *Divinity*, whereby He is distinguished from all Creatures that have had a Beginning; and thus speaking in his Epistle to the *Romans*, *Ch.* i. *v.* 20. *The invisible Things of him from the Creation of the World are clearly seen, being understood by the Things that are made, even his Eternal Power and Godhead; so that they are without Excuse:* And shewing likewise, that in naming the Creatures in general, he excepts nothing out of 'em, how small soever it may be, which by its Existence is not capable of convincing, with the utmost Certainty, every one that has not quite lost the Use of his Reason, of God's *Eternal Power* and *Divinity*, that is, among other Things, of his *Eternal Existence.*

Sect. IV. *The Contemplation of Ourselves in general.*

Now as this Contemplation of all Creatures in general, after the aforesaid Manner, is a Testimony to every Man's Conscience, that there is an Eternal God; so likewise will every Man that only views the Frame and Construction of himself, (and considers who he is, and whereof he consists; how he is come into this World and supported therein,) from thence be convinced of the Wisdom, Power, and Goodness of such a God, without hardly considering any other Particulars, tho' we hope also to Account for them hereafter.

He, therefore, who has hitherto denied or doubted of so weighty a Truth, let him turn his Eyes and Thoughts first upon himself only, when he cannot but confess, that he has a Body, of which, being in Health, he is capable to move some Parts, such as the Hands, Feet, Eyes, *&c.* arbitrarily, and according to his own Pleasure; and again (which is very remarkable) that his Will has little or no Influence or Power over other Parts; thus his Heart beats, his Blood circulates, his Stomach and Bowels are moved; the Humours and Fluids, which compose so great a Part of his Body, produce several Effects

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in him, without his being able either immediately to hinder or promote their Operation: Moreover, he finds that he Understands, Wills, Reasons, Loves, Hates, Fears, Hopes, and (in one Word, that Philosophers commonly make use of to Sum up the whole) that he *Thinks*.

Sect. V. *The Contemplation of our Body, which is Earth.*

Now upon enquiring first into our Body, we are convinced by certain Experience, that the same consists of the Food we use, such as Herbs, Fruits, Corn, Flesh, Fish, Water, and the like. The Beasts have likewise their Food; and tho' these eat one another, yet the Food of most of them consists of Plants and Water; for as for Fossils, Metals, and such like, we do not yet know that they serve for Food to any Creatures; and tho' they should, yet the following Proof will remain in its full Force.

Now all these Plants spring out of the Earth, and being sown, seem to draw their whole Substance from Earth and Water, excepting only what Air, Light, or such like Matter, may contribute thereto; which Mixture of all together, because we meet with it in all fruitful Soils, we shall hereafter, for brevity sake, call by the common Name of Earth.

From whence then a Man must finally conclude, that the Matter whereof his Body consists, is nothing but the Water he uses in his Drink, together with an alter'd and disguised Earth, which first becomes Plants, and afterwards is turned into the Substance of his Body.

Now if all this does not appear clearly enough to him, let him suppose the Person of a Man, who having been before very Fat and Heavy, has lost some Pounds of Fat by Sickness; if such a Man being restored to his Health, and using no other Food than Bread and Water, should again attain to his first Weight, whence proceeds this his new Flesh, but from the aforesaid Bread and Water? But more especially, if he considers the Smallness of his Body in the very beginning, which when his Mother first conceived him, was scarce of the Weight of half an Ounce, tho' the same Body afterwards, first by the Nourishment it received from the Mother, and afterwards what it took in it self (both which, with respect to the Matter of it, can be called nothing but Earth) grows up to a Man of so many Pounds weight; and will he then still doubt, since all this Nourishment consists of Water and Earth only, whether his whole Body, in its utmost extent, is any thing else but a Metamorphosed Earth?

Sect. VI. *That the Body does not think.*

Having now discover'd these Things concerning his Body (that we may advance a little farther) let him suppose himself sitting with another Person at Dinner, could he think that the Bread, Flesh, Fish, Beer, Wine, *&c.* that are eaten and drunk, should first become Nourishment, and afterwards being turned into his Body (or rather, that a quantity of Earth, from whence this Nourishment proceeds) has the Capacity to judge of, and to understand his, or another Man's Discourse; or can comprehend the Demonstration of a Proposition in *Euclid?* or let him consider, whether a skilful Chymist and

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Philosopher could ever justly fancy to himself, that he was able to produce, out of such Food or Nourishment, a solid or fluid Body (besides which two, no third can be shewn) that can Think, Reason, and Discourse like a Man? Now I cannot bring my self to such a Belief, that there ever was any Man, who desired to pass for a Person of the least Sense, capable of advancing such Notions, and intrenching himself in the same, against an approaching Eternity.

Sect. VII. *The Soul demonstrated.*

All this being duly weighed, can a Man make any other sort of Conclusion, than that his Food, consisting of Earth and Water, is the Substance of his Body; and that nothing of those, or of any thing else produced by those, (nor consequently his Body) is capable of *Understanding*, *Reasoning*, or *Thinking*.

And yet he is assured, and plainly convinced, that he both *Understands*, *Reasons*, and *Thinks*: This therefore is an irrefragable Proof that there is something else in him besides his Body, which *Understands*, *Reasons* and *Thinks*; so that he does thereby know so much of himself, as that he is composed of two distinct Substances, *viz.* of a Body which is Earth, and of some other Thing besides his Body, which other Thing *Understands*, *Reasons*, and *Thinks*: This last is called the *Soul*; and therefore he knows that he does consist of a *Body* and *Soul*.

Sect. VIII. *No Man proceeds from himself, nor from his Parents, but from another.*

Being come thus far, and knowing what he is, let a *Sceptick*, or an *Atheist*, go a little farther with us, and endeavour to find out how he came into this World, and how he is here supported.

And that he may bring himself to consider the same experimentally, let him examine himself, and see, if it was in his Choice or Power to be here or not, whether he would choose to be formed Sick or Healthy, Blind or Seeing, Streight or Crooked: To all which, without doubt, he will answer, that he would rather be form'd with the good Qualities. On the contrary, let him by his own Experience enquire, whether he be not placed here without the least Act or Concurrence of himself, and entirely without his own Knowledge in the Condition wherein he finds himself, and wholly uncapable of bestowing on himself more or fewer Advantages of Nature: Consequently then, he must be convinced that he does not proceed from himself, but from another.

But supposing it should be objected by some body (who being wavering and full of Doubts, and unwilling to consent to what has been here advanced, least he should be forced to acknowledge a God) that his Parents were, by way of Procreation, the first Causes of his Existence in this World; which at first sight carries something specious with it: yet if he will be pleased to penetrate farther into the Matter, he cannot refuse believing, that his Parents, as well as others, owe their beginning to that desire of propa-

gating their Species, which is naturally implanted in all Creatures; without any Certainty at the same time, or Thought of the Consequences of such an Act: And must he not, moreover, confess, that none of 'em all were capable of knowing or saying whether it should be a Man or Woman, a deformed or well-shaped Child that was to be produced? Yea, after the Birth, does it clearly appear to either of the Parents, how the Body of such a Child is framed, with respect to its Veins, Nerves, Flesh, Bones, Humours, and other Parts?

Now if all this be brought to pass without the Knowledge of the Parents; if they be entirely ignorant of the Composition or Structure of their Child, how can he look upon them as the true Cause of his Being and Subsisting? Can one justly hold that Person for the Artificer, or the real Cause of any Machine, who is forced to own that he does not know any thing of the Construction, nor how it came to be so made? and yet more, who did not so much as know even whether it was made by him, tho' he did all that lay in his Power towards the Production of it?

And since he cannot judge that his Parents have contributed more to him than others do to their Children, must he not own, that it follows from thence, that he is placed here entirely without his own Concurrence, and without being able to prove that his Parents are any thing else but unknowing, and consequently no true, but at the most, instrumental Causes only of his Existence?

Moreover, to the end that we may obviate all Evasions, and demonstrate undeniably that he cannot be produced by his Parents as true Causes, let him recollect, that besides his Body, there is a Soul, of which he consists, which has been already shewn to be entirely different from his Body: Now all that could happen towards his Production on the part of his Parents, seem only to have respect to his Body, and consists in nothing more than in the Communication of the *Semen Corporeum*, which likewise has its Original from Food and Nourishment; and therefore, according to what has been proved above, is nothing else but Metamorphosed Earth and Water. Now this Earth and Water, or any thing else that proceeds from them, does neither Understand nor Think, and yet he himself does both; for which Reason he ought certainly to be convinced, that he, as a Man, that is to say, as an Intelligent, Rational, and Thinking Creature, can by no means owe his Being to his Parents; and since he cannot be the Cause of himself neither, he must therefore, as well as all his Forefathers, have been brought into the World by some other Being.

I have here in the Beginning, that I might not seem to argue too acutely, passed over those Modern Observations, by which it is pretended, that the Humane Body draws its Origin from a *Stamen*, or Fundamental Principle, in which the Members are rolled up as in a Clew or Ball of Thread; which afterwards, by the Help of Nourishment, is filled up and unfolded to a Visible Body. The Reason is, because the Proof which we have here in View, would still remain of the same Force. *First*, Since this *Stamen*, how small soever it may be, whilst it continues unfolded, is nevertheless a real Corpo-

real Substance. *Secondly*, Because it is not yet proved, that this *Stamen* does not proceed from the Fluids of the Father or Mother, or of both, and therefore does likewise consist of disguised Earth. *Thirdly*, By what Cause soever this *Stamen* is produced, it cannot be denied, that when it is quite unfolded into a Visible Body, it is nevertheless a Corporeal Substance, and so remains. Now that such a Substance can Discourse or Think, no Body that would pass for a Wise Man will rashly affirm; nor do I believe neither, that there was ever any one found who would persist in this Notion, That we ought to ascribe the true and real Cause of the Formation of our own *Stamen*, or of any other Humane Body, to our own Knowledge, or to that of our Parents: Whoever, therefore, does any Thing ignorantly and unknowingly, cannot, as we have said before, be consider'd any otherwise than as the instrumental, but by no Means the true Cause of any Effect; from whence it follows, That the Conclusion must remain as it did; namely, that neither our Parents, nor we our selves, are the true Causes of our Existing here.

Sect. IX. *That our Support is from Another.*

Now after the above-mention'd Discoveries, it may easily be made appear to every Man, that as he is not placed here by his own Power, so neither is he supported by the same: For if he were, he might at least provide Food and Nourishment for himself; but can he make the Sun to Rise, which causes every Thing to spring out of the Earth? Can he bring down a Drop of Rain from Heaven, which renders the Ground so Fruitful, and which likewise must serve him for Drink? Can he communicate an Existence, and the necessary Properties to one single Ear of Corn, or to the smallest Blade of Grass, in order to feed himself, and those Creatures which he uses for his Nourishment? But to go yet farther, supposing he had Food in abundance, can he tell after what manner his Body is thereby supported? Or does he know where that which refreshes his Body remains, as soon as it has passed thro' his Stomach and Bowels, and how his Food is turned into Blood and other Juices, and how they again are converted into such different Parts, of which his Body consists? So that here again he can conclude no otherwise, than that all this surpasses his Power, and that it is nor by himself, but by some other Being, that he exists and is upholden.

Sect. X. *And this other Being, either knows, or is ignorant of what he doeth.*

Now being thus far assured, from what has been said, that a Man is not produced by himself nor by his Parents, but by some other Being, by which he is likewise supported, I leave any one to judge, whether he can live in a perfect Tranquility, without endeavouring to know what kind of Being it is by which he is Made and Supported; since I cannot think that he is so insensible, or so little affected concerning those Things that relate to his own Happiness or Misery, as not to look upon this to be an Affair of the utmost Imporrance.

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If then he will endeavour with us to enquire into these Matters, he must at least acknowledge for an undeniable Truth, that the Cause by which he is here placed and supported, does either know and understand its own Actions, or else is entirely ignorant of them; that is, he must either agree with the wisest part of the World, that there is a GOD by whom he is made and supported, who knows what he did, and what he daily does, with respect to him; or else he must endeavour to perswade himself, pursuant to those Principles of unhappy *Atheists* (which have never yet been demonstrated) that he was brought into the World by a meer and ignorant Chance, or by a necessary Consequence of the Laws of an unknowing Nature: One of these must be undoubtedly true.

SECT. XI. *That our Maker and Preserver is Wise, Mighty and Merciful.*

NOW in order seriously, and without Passion or Prejudice, to consider so important a Matter, and to know which of these two Questions are to be received for Truth; let him suppose, that he were to be brought into a Room, where he should see several Clocks and Watches that have been adjusted with all the Skill and Perfection the Artificer could exert, so that they went very True and Regular; and then let him ask himself, whether he thinks those Machines could acquire their Existence and Aptness to perform their several Functions, without the Concurrence of the Skill and Judgment of a Workman, and only by Causes that were ignorant of the Effects they produced, such as meer Chance, or necessary Laws of Nature? and whether he would not judge that any Man, who should undertake to deduce such Conclusions from his own Philosophy, were not quite out of his Senses?

After having maturely consider'd all this, let him proceed farther, and instead of Clocks, let him cast his Eyes upon the Frame and Construction of his own Body, or upon that of Beasts, Birds, Fishes, Plants, and other Wonders of Nature, and think, since a good Clock does undoubtedly prove its Workman skilful, whether in each of these last mentioned Things there does not appear an Art incomparably greater than that which shews it self in the very best Clocks? forasmuch as it is most certainly true, that the best Artificer in the whole World, is not capable of producing even a Mouse or a Fly, a little Flower or a Plant, tho' never so small, in such a Perfection as we see them daily appearing. Let him therefore silently examine himself, whether all his Atheistical Arguments can bring him to embrace these miserable Notions for Truth with Tranquility, and without a continual Remorse of Conscience, *viz.* that he who made his Body, and all these Things after so wonderful a Manner, and out of such improper Matter as the Earth appears to be for such a Purpose, should be so far void of Wisdom and Understanding, as not to know after what Manner, nor to what End, he had made the same?

Now since an unhappy *Atheist* seems to be unavoidably obliged by all these Things, to acknowledge that his Creator is wonderfully Wise; since, moreover, the Manner whereby he is preserv'd, seems to convince him, that this his Preserver is not only Wise, but also Mighty and Merciful; having most

bountifully provided such a great Body as the Sun to give him Light, the Air surrounding this whole Earth for Respiration, so great a quantity of Water to assuage his Thirst, such a number of Plants and living Creatures to satisfy his Hunger, and to refresh him, and so many other Things for other Uses, without any Co-operation on his Part, and such wonderful Faculties for the Enjoyment of them all: Let him finally consider with himself, what he ought to expect, even in his own Judgment, from the just Wrath of this his Maker and Preserver, in case he continues to deny his Wisdom, to despise his Power, and to be ungrateful for his Mercies, and in order to free himself from the Obligations he lies under to Providence for all these good Things, if he continues to ascribe them all entirely to insensible and ignorant Causes.

Sect. XII. *The Transition to the following Contemplations.*

I can scarce think it possible, that there should still be an *Atheist* so deplorably obdurate, after having weighed all these Things most seriously by himself, as to dare to own, that the Consideration thereof does not make him uneasie; and in case there should be any that had so far abandon'd themselves to their seducing Passions, yet it is not to be imagined, that all of 'em have so greatly renounced their Reason, as not to think it worth their while to pass on with us to the Contemplation of the Works of the Great Creator in the following Discourses; or that among so many Particulars and Wonders, which they will there meet with, there should not be one single one sufficient to make them see their Error, and to give them a convincing Proof of a Deity shining out so brightly from thence. This I can say experimentally, that by the Meditation chiefly of what has been here offer'd in these two first Contemplations, an unhappy Person, whom I had formerly often besought, while he was in good Health, that he would seriously weigh these Things by himself (and who was wont, even till a few Weeks before his Death, where-ever he could speak his Mind freely, to ridicule all such as acknowledged and served a God) was by God's Grace brought over to better Thoughts, and to a Conviction of his Existence, as he confessed to me with his own Mouth in his last Illness.

CONTEMPLATION III.

Of some Particulars in the Mouth.

Section I. *Concerning the Teeth.*

To begin then; let us first contemplate our own Body, and all the wonderful Structure thereof; which, tho' the most part of our Food, as Bread, Flesh, Fish, *&c.* consists of solid Bodies, cannot be nourished by them so long as they remain such, and are not first converted into Fluids; wherefore a Means

a Means was requisite to turn these solid Bodies into a liquid Matter, and even such as should be proper to support and nourish us.

For this Purpose there are *Teeth* planted in our Mouths, of which those that stand foremost are sharp and cutting, in order to bite off a Part of that Food which is taken in, whose Semicircular Figure is wisely adapted to a just Measure of the Piece to be bitten, and so as to be afterwards chewed with the most Conveniency, as every one may experience who makes his Biting greater or smaller: The second Sort are those that are called *Dog-Teeth*, and those are more pointed than cutting, and seem to be particularly designed for something that is tougher and harder, and which cannot easily be penetrated by the former, in order to hold it fast, and so to divide it from the other Part.

Does there not appear a wise End in all this? Why are not the following Teeth, which are call'd Grinders, of the same Figure? Why are they flat and broad, and uneven, with Cavities and Protuberances, as if Nature intended, that what was bitten off by the foremost, should be beaten small and ground by these latter, to which their Unevenness contributes, as it is in some Mill-Stones that are made uneven on purpose, in order to grind the better? If this is done by Chance, why don't the Grinders stand foremost, and the Fore-Teeth in the inward Part of the Mouth, which would certainly render Biting and Chewing very uneasie? How happens it, that almost all the other Bones are clad with a tender and sensible Membrane; but the Teeth, so far as they stand out of the Gums, with none; unless it were to avoid that Pain, which the Use of 'em in Biting would occasion, by pressing upon such a Membrane?

Sect. II. *Of the Enamel of the Teeth.*

Can any one suppose, that it is without Wisdom and Design (since the naked Bone can rarely endure the Air without Corruption, and the Covering it with a Membrane would be here useless and inconvenient) that the Teeth are surrounded with a hard Substance, which the Author of the *History of the* French *Academy of Sciences*, for the Year 1699, *p.* 48, calls the *Enamel*; wherewith they are, as it were, glazed round about, so far as they are exposed to the open Air; and which, as soon as they lose, they rot and are corrupted. In *Tab.* I. *Fig.* 1. you may see a Representation thereof: The Line A C F H is that Part of the Gums out of which the Teeth appears; A E C and F G H are the Roots of the Teeth: The Parts A D C B and F L H I I shew the *Enamel* or Glazing, which consists of small Fibres running parallel to each other, that join sometimes at the Top, but below are separated from each other: This Enamel covers the whole Tooth as far as it stands out of the Gums: M M are the little Holes thorough which the Nerves pass into the Root of the Teeth of young People, but are closed in Old, as in N N; by which Means this Part of the Nerves, which are otherwise in the Teeth, is separated from the remaining Nerves.

The

The Bone of a Tooth is remarkably harder than all other Bones, and is therefore thought by some to be of a petrified Substance, to the End that it might not become useless by Attrition: And whereas other Bones cease growing after a certain Age, the Teeth, or at least their Enamel, increases even to old Age, in order to make good the continual Wearing of 'em; this appears when we lose a Tooth out of one of the Jaw-Bones, that which is opposite to it in the other becoming oftentimes longer than those which are next to it.

Sect. III. *Of the Lips.*

To say no more of other Uses of the Teeth, with respect to the Beauty of the Countenance, and particularly for Speech, which by their Means becomes intelligible, easie and distinct. Who can consider the Structure of the *Lips* without Astonishment, and their Motion in such various Manners? The Opening of them for the Reception of Food; the Closing of them again to prevent the same Food, whilst it is chewed, from falling out of the Mouth; the Use of 'em in Humane Speech; by these the Children suck their Mother: And these, together with the Tongue and Cheeks, are useful in chewing the Food, which not being able to remain under the Jaws and Teeth, is by them, at every Turn, brought back again, till it becomes small, and sufficiently moistened by the Spittle.

Sect. IV. *Of the Glands of the Mouth.*

Is it not likewise by a wise Contrivance, and not by meer Chance, that there are in the Mouth so many Glands or *Fountains of Spittle?* Since if the Food should remain dry, it could not be swallowed down, but with a great deal of Trouble; whereas the Moisture that proceeds from them, by innumerable Orifices, is mingled with the Food whilst it is chewed; and this Liquor, or Moisture, is brought thither by long Vessels, and distant Glands, not only to the aforesaid End, but (which is more) to give an Occasion for the more easie converting the solid Food, wherewith it is mixed in the Mouth, into a nutritious Liquid Substance in the Stomach. We shall not here mention the Property of Spittle in causing many Things to ferment, or its other Qualities, which may be found in the Writings of those who have enquired into them, because we will not dwell too long upon this Subject.

Sect. V. *Of the Tongue.*

Before we take our Leave of the Mouth, I cannot forbear observing something more therein, which every one that sees the Effects of it, must needs be astonished at: This is the wonderful Structure of the Tongue; and here I would freely ask all the Artificers in the World, whether any of them could have invented such a Machine, which having neither Bones nor Joynts, can produce such an innumerable Variety of Motions; sometimes making it self long and thin, at other times short and thick; and in a Minute stirring and turning it self after so many particular Ways, that one can scarce fancy any kind of Motion of which it is not susceptible.

Can

Can any Body think that there is neither Understanding nor Wisdom made use of here by Him who has formed such a wonderful Body, only by the knitting together of some Muscular Fibres (if we except some Glands, the Use of which is to moisten it, as it becomes dry) and fix it in a Place where all these Motions may have their Use?

This Tongue lies in the Mouth, where the Sound that comes out of the Wind-Pipe passes thro'; and which, by the Motion of the Tongue, becomes distinct; and so forming all Speeches and Languages, produces this great Wonder, that a Man, by the Motion of such an Instrument, can communicate the Thoughts of his Soul to another; whereas, if it were otherwise placed, or if it were not of such a Texture and Property, the whole World would be brought into Confusion: This may be observ'd in those, who by Deafness or other Accidents have the Misfortune of not being able to use their Tongue; how great is the Trouble and Difficulty they find in expressing their Thoughts to other Men? In short, every one may easily represent to himself what a Disorder it would be, supposing all Men dumb, if we were obliged to make use of other Signs and Tokens, in order to carry on any Commerce or other Business with one another; not to mention the Prejudice which the Teaching of all Sciences, and in a manner every thing that passes among Men, would suffer thereby.

The Tongue does also lie upon that Place thro' which the Meat and Drink passes; and besides its other Faculties, is a principal Instrument of Tast. If it had not this Property, how many People would eat without any Pleasure or Satisfaction? Nay, so necessary a Work would be very tedious and irksome to many.

Not to mention here expresly that Service and Use of the Tongue which preserves all Men alive, *viz.* by thrusting the Food, after it has been chewed in the Mouth, down the Throat; without which we should not be able to swallow at all, or at least but with great Difficulty; the Inconveniencies of which, all such as have lost this Faculty by Swellings in those Parts, are very sensible of.

Sect. VI. *Of the Throat.*

Now if we pass on to the Throat, whither the Food leads us from the Mouth and Tongue, and if we consider the Structure thereof; can any one imagine that it was so contrived without any Wisdom, that the Oesophagus or Opening of the Throat, is dilated by three Pair of different Muscles (see *Tab.* I. *Fig.* 2. BB, CC, DD,) like a Bag by six Hands, to the End that the Food, which the Tongue drives thitherwards, may be swallowed, and descend without any Trouble; being drawn up so much higher backwards, by the Muscles DD, that the Food passing over the lower Brim thereof, and striking against the hinder Part, should not fail to find the right Entrance of the Throat, which being composed of a moist Membrane, would close together, or at least hinder the Swallowing, if those Muscles were not placed there.

Sect.

Sect. VII. *Of the Wind-Pipe.*

But herein appears yet more sensibly the Design and Wisdom of the Great Artificer, in ordering the Food to pass over the Orifice of the Wind-pipe as it goes to the Throat: For if any Thing falls into the Wind-Pipe (which People commonly call *going the wrong Way*) every one knows what Disorder it occasions in them, so great sometimes as to put them in danger of choaking; wherefore it is absolutely necessary, if we would eat with Ease, and preserve our Life at the same time, that the Wind-pipe, or the Mouth of it, should be closed when we swallow, and then immediately open'd again, in order to draw our Breath: Now can any Body be so dull as not to observe this determinate End and Design of our Wise and Merciful Creator? Let him only take the Trouble of viewing the upper Part of the Wind-pipe of a Sheep or a Calf, where he will see more plainly than can be shewn him here by a Figure, that there lies a Cartilage, called the *Epiglottis*, which being pressed down by the Food, when 'tis swallowed, covers the Orifice of the Wind-Pipe lying under it; by which Means the Food passing over it, as if it were a Bridge made for that Purpose, in its Way to the Throat, is prevented from falling into the Wind-pipe, which would often occasion Coughing, Straining, and other greater Inconveniencies.

Now if this Cartilage should remain lying thus upon the Orifice of the Wind-pipe, the Breath would be stopt, and the living Creature immediately suffocated. Do we not here again discover a wise Design, that this *Epiglottis* is so contriv'd, as to rise up like a Spring that has been pressed down, or as some say, drawn up by Muscular Fibres after the Food has passed over it? By which Means the Passage of the Breath is immediately open'd after swallowing, in case the Elastical Force of the said *Epiglottis* should be weaken'd by too much Use.

Sect. VIII. *Convictions from what has been said above.*

Now let a Man consider all these Things together, as they appear in so small a Place as the Cavity of the Mouth, and see whether he can still suppose that all of them, so manifold in Number, so necessary to our Life and Well-being, could have met together in such a narrow Circumference without any Design of the Maker, and by meer Chance or ignorant Causes? Can he not clearly discover therein a Wisdom, Power and Goodness, which contrived all this, in order to support this Part of the Humane Body, and to preserve it from sudden Death by Suffocation or Strangling? And let any one say, if he can, that in a Place not above a Span long, where so many Dispositions of so many different Things, for the attaining such weighty Purposes do appear, that all this is brought about by Causes ignorant of their own Work.

Sect. IX. *About Sucking, and of Places from which the Air is exhausted.*

Before we conclude this Discourse, I must add something, which as often as I consider it, does every time excite in me a new Astonishment.

All the Learned World knows the just Praises that have been given to the famous *Torricelli*, *Gueric*, *Boyle*, and others, who were the first Inventors of the Art of producing a *Vacuum*, or Place void of Air, by the sinking of Quick-Silver, or otherwise by Air-Pumps, whereby so many Secrets of Nature have been discover'd. And can we see without standing amazed at the All-comprehending Wisdom of our Great CREATOR, who has prepared and fitted the Mouth of all Men for an Instrument to produce the same Effect? The Action which is called *Sucking*, is a plain Demonstration thereof, and is performed by putting the Tongue and Lips together, or otherwise, only by leaving a little Cavity between them first open, and afterwards drawing the Tongue backwards, which makes a Hollowness that was not there before between the Tongue and Lips, and consequently empties it of Air; or otherwise, by drawing the Tongue back, makes the Cavity that was there larger, giving the Air that was in the Place more room, and so lessens the Pressure and Resistance of it in that Place; by which Means the Liquor (into which one End of a Pipe is put, and the other into the Cavity of the Mouth, which has been emptied of its Air) being pressed by the External Air, and finding in the Mouth little or no Resistance, is forced up thither: The same Effect is seen in the Sucking up of Smoak by those that take Tobacco.

SECT. X. *Sucking, as performed by Children.*

BUT that which ought to be not only surprising, but astonishing to every Body, is, that this so artful a Manner of producing a *Vacuum* is performed by Children newly born, and even by all the most irrational Creatures, which, by Sucking their Drams as soon as they come into the World, are already taught to begin to support their own Lives. Can these know that the Air has an expansive Faculty? That it presses all things with so great a Weight? That to cause the Milk to come out of the Breast with such a Pressure, there must be a *Vacuum*, or Place void of Air, made before the Orifices of the Nipples? That this Place must be so closed on all Sides, that tho' the Air, in order to Respiration, passing thro' the Nostrils, can insinuate it self by the smallest Opening, yet it must be prevented from coming into this *Vacuum*; for in such a Case the Sucking, or the Flowing of the Milk, would cease: All which things must be well observ'd by such as make Instruments proper for Sucking, as they are exactly followed by Nature.

SECT. XI. *Convictions from the foregoing Observations.*

NOW let the unhappy Patrons of the desperate Sentiments of an *Epicurus* and *Lucretius* seriously consider these things with us, and see whether their Fundamental Principle can obtain here, *viz.* That all things are produced without a certain End or Design of the Creator, and that Men only finding 'em so prepared to their Hands, do make their Use of them. Is it to be believed that this can happen with Children, and all other Creatures, as soon as they are born, which do not so much as know that there is such a thing as Air, much less how to apply it to this Purpose? Can any Man,

endow'd with Reaſon, think, that the dulleſt and moſt ignorant of all living Creatures are immediately capable to apply ſuch a Machine to its right Uſe? Whereas Men of the greateſt Learning and Underſtanding will readily own how difficult it is at firſt for them to underſtand and uſe the ſame rightly; every one can witneſs this the firſt time he takes an Air-Pump into his Hand.

And to give a convincing Proof that the Inſtruments made uſe of by Children and young Creatures in Sucking, are produc'd by infinite Wiſdom for that Purpoſe, we need only enquire into the wonderful Structure of the Muſcles of the Lips and Tongue, and the fleſhly Fibres of which they are compoſed, and which are ſo well deſcrib'd by all Skilful Anatomiſts. If we would allow Reaſon to take place, we ſhould be ſufficiently ſatisfied by this ſingle Inſtance; that, becauſe that Paſſage is ſtopt in Sucking, which upon other occaſions is prepared for the Air, the adorable Creator, and great Supporter of all things living, has ſo diſpoſed the Noſtrils, that they may ſerve for Breathing, during the Action of Sucking; and ſo this great Work, ſo neceſſary to New-born Creatures, might not be obſtructed at every turn. A Proof of this is ſeen in Nurſes, who, when they have a mind that the Child ſhould leave off Sucking, ſtop their Noſe with their Finger, by which Means their Breathing that way being hindered, they immediately quit the Breaſt, that they may draw in the Air by their Mouths.

CONTEMPLATION IV.

Of the Throat, Stomach, and Bowels.

SECT. I. *Concerning the Throat.*

LET us now go on, and contemplate the Structure and Function of the Throat, as it extends it ſelf from the Mouth to the Stomach.

The Food being ſufficiently chewed in the Mouth, and being conveyed in the Manner as has been before deſcribed, into the Throat, thro' the Orifice or Opening thereof, (*Tab.* I. *Fig.* 2. E) if it were to deſcend by its Weight only, it would require a great deal of Time to paſs into the Stomach; thro' this Tube, becauſe of its being membranous and moiſt; ſo that the Parts of it would ſtick together, eſpecially, if any piece of Food, by its Largeneſs and Solidity, ſhould extend the Throat in its Deſcent, and thereby contract thoſe Parts that are above and below the ſaid Food; to ſay nothing of the Throat of Beaſts, which lies horizontally, or even aſcends when they feed upon the Ground; in ſuch a Caſe, I ſay, that which is ſwallowed would not be able to proceed into the Stomach.

Now,

Now, to prevent all theſe Inconveniencies, it has pleaſed the Gracious Creator, to place there a Muſcle, A A, (which is here repreſented, cut thro', and is by ſome taken for two) the Fibres of which encompaſſing the Throat, and contracting themſelves, do thereby ſqueeze it, and ſo force the Food to deſcend; for whatever the Cauſe be, it is experimentally true, that all the Muſcles of the Body operate, by contracting or ſhortning their Fibres.

Sect. II. *The Strait and Circular Fibres of the Throat*

Can we further conſider the wonderful Order in which this Tube is framed, without acknowledging a Wiſdom therein that intended the Protruſion of the Food into the Stomach? Since the outward Membrane E being taken off and laid aſide at *a* (which is to be underſtood in all thoſe Places where you meet with the Letter *a* in this Figure) the Muſcular Fibres F ſhew themſelves deſcending perpendicularly, or lengthwiſe, according to the whole Extenſion of the Throat; having others under them, as in G, which encompaſs the Throat like Rings or Circles: Let us now imagine, that theſe two ſorts of Fibres, *viz.* thoſe that run lengthwiſe at F, and the Circular at G, were contracted; we ſhould then perceive that theſe laſt Circular Fibres, ſhortening themſelves behind and above the Part where the Food lies, protrude the ſame downwards, after the ſame Manner as the Women that make Sauſages are wont to do, by ſqueezing the Matter with their Hand, in order to make the ſame go forward into the Bag or Gut that is to contain it; whilſt in the mean time, the long Fibres, by ſhortening themſelves likewiſe, do widen the Place thro' which the Food is to paſs, to the End it may be the more eaſily thruſt down by the Contraction of the Circular Fibres.

Now that this Motion and Progreſſion of the Food towards the Stomach is perform'd by ſuch a kind of Force, and not by its own Weight, is plain by Childrens ſwallowing their Victuals into the Stomach upwards when they ſtand upon their Heads: Upon which Account every one of us is moſt highly obliged to the Goodneſs of our Creator; becauſe otherwiſe no body could take in any Food in the Poſture of lying down; which how exceeding inconvenient it would be to Sick and Diſtemper'd People, is not neceſſary to be farther deſcribed.

Sect. III. *Of other Tunicles or Coats of the Throat.*

One Thing further ſeemed requiſite towards rendering the Paſſage of the Food yet more eaſy, *viz.* That the Tube above-mention'd, for the better performing its Function, ſhould be kept conſtantly moiſt; foraſmuch as the Food being ſometimes dry, its Motion and Deſcent would be perform'd more ſlowly and with greater Trouble.

Can we therefore diſcover no Wiſdom herein; that in order to produce ſuch an Effect, the ſaid Throat has a Tunicle full of Blood-Veſſels, that is of Veins and Arteries, (See *Tab.* I. *Fig.* 2. H) and yet another under that at I, which is called the *Glandulous Tunick*, becauſe it is full of little Glands, from whence a Liquor is ſeparated from the Arteries, which renders the

under-lying K, called the *Nervous* Coat, smooth and slippery, that it may be fit for the said Uses? It ought likewise to be observed here, that these Glands in this Coat or Tunicle are placed exactly between fleshy Fibres for this Reason, that thereby they may be more or less pressed, in order to discharge their Moisture according as there is Occasion; for which Cause likewise, this last Tunicle is endued with a soft Woolineſs on the inside, which in some measure is able to stop and hinder the Moisture from passing away till it has performed its Function of making the Parts slippery: when there is too little of this Moisture, and the Throat is too dry, that which we call Thirst, seems to be produced, which is a natural Warning that Moisture is there wanted.

Sect. IV. *Convictions from the foregoing Observations.*

Now can any one imagine, that all this wonderful Structure of the Parts of the Throat is produced by Chance, without any View or Respect to the Order and Uses for which they are designed? which besides those Artful Instruments for forcing the Food to descend into the Stomach, besides the Veins that feed it, and by the Moisture which is separated in the Glands, contribute to make it smooth, has likewise in it self the Property of warning us when we ought to moisten it, at such Times as its own Natural Juices are not sufficient to perform the same, by reason of the Dryness of the Food, or other Accidents; and if any Body does persist in affirming, that all this is owing to Chance, why should he be ashamed to say, that a Spout or Pipe by which the Rain-Water is conveyed from the Top of a House into a Cistern (which in Comparison of the Structure of the Throat, has nothing of Skill in it) was produced into that Place by meer Accident, and without any End or Design?

Sect. V. *Of the Stomach.*

Now in Case the Stomach D C D T, (*Tab.* I. *Fig.* 3.) were as narrow as the Throat E A, or as the Intestines G H H I I, both which make one and the same continued Tube with the Stomach, and that the Food should pass thro' all of them with equal Force and Swiftness, it would not be possible that the same should be rightly prepared, or, as they call it, macerated and converted from a solid Body into a fluid Matter proper for Nourishment.

And here again do we not see plain Footsteps of a Wise End in contriving the Stomach to be so much larger and hollower, in order to contain at once all the Meat and Drink that is sent down into it? and besides, of such a Structure, as not to suffer the same to pass too soon thro' it, as it happens in all the other Parts of this great and long Tube?

Thus we see, that the Food descending from E A into the Stomach B, is hinder'd from proceeding further, by Reason that the extreme Part or End of the Stomach C, by which the Food is to be discharged, is so much higher than the Belly of it in which it lies; whereby it is obliged to remain there for a while, in order to be turned into a sort of Pap, which the *Anatomists* call

Chylus or *Chymus*; or, as some will have it, till the Quintescence thereof be extracted.

And what I cannot pass over here without a Note of Admiration is, That according to the Observations of that great Anatomist *Verheyen*, the discharging Part C is not raised up to that heighth, but just at the Time when the Stomach is full and extended, and so is capable of hindering the Food from passing too swiftly thro' it; whereas otherwise, when the Stomach is empty, it sinks down much lower. Can any one see this without discovering the Design of the Great Creator, to continue the Food a sufficient Time in the Stomach?

Sect. VI. *The Fluids of the Stomach and Muscular Valve.*

Now whether the Consumption of the Food happens after one or the other Manner, it was necessary in both Cases, that there should be more Moisture mixed with it in the Stomach, in order to put it into a Fermentation, or otherwise to convert it into that fluid Matter called *Chyle*.

Can it now be thought, that meer Chance produced such a vast Number of Arteries in the Stomach as you may see at D D, *d d*; and such a wonderful Number likewise of Nerves, spreading like so many Branches out of E and F, which convey into it such a Moisture and Nervous Juice by the Glands that are placed on purpose, that together with the Spittle which is mixed with the Food in Chewing, they may make a new Liquor proper for the Attrition or Breaking of the Food; and to the End that it may remain long enough therein, the extreme Part of the Stomach B, (*Tab.* I. *Fig.* 4.) is shut up with a Muscle, that encompasses and contracts the same, and which therefore cannot be opened but with a greater Force or Pressure?

Sect. VII. *The Fibres of the Stomach.*

The Food having remained some Hours in the Stomach, in order to its Change, must afterwards pursue its way for the Nourishment of the whole Body. Can any one then think that it happens without the especial Wisdom of God, that every Thing is found in the Stomach adapted in the best manner to promote this Purpose?

1. By the insensibly oblique Ascension from the Bottom of the Stomach to the Passage C (*Tab.* I. *Fig.* 3.) in order to discharge the same: Whereas if this last Orifice was of the same Structure as that at A, thro' which the Food passes into the Stomach, it is plain, that the Discharge thereof could not be performed but with very great Trouble.

2. Add to this, that the external Fibres of the Stomach are extended lengthwise in it, and being shorten'd in their Operation, they likewise render the Stomach so much shorter; and in order to exert themselves with greater Strength at both the Orifices A and C, as also at the Bottom of the Stomach, they become musculous.

3. Moreover (*Tab.* I. *Fig.* 4.) other stronger Fibres D encompass the Stomach annularly, and cross the former, which being drawn together, make the Stomach narrower.

4. Under

4. Under these there lie yet another Row of Fibres (*Tab.* I. *Fig.* 5.) which run obliquely A, extending themselves from the uppermost Part of the Stomach to the Bottom thereof, drawing obliquely the End M towards the Beginning N.

Now let any one suppose, that he held this Stomach C T full of a fluid Matter in his Hand, and that it was to continue in the same Position in relation to the Heighth of its lower End C: Could he possibly invent a better Way to discharge the said Matter by the Orifice C, as first by closing the Orifice A, and afterwards contracting the Stomach, by pinching it together length-wise from C to A; by which Means the inclosed Matter being thrust against the Left end of the Stomach T, must necessarily be forced out at the Right end where the Orifice C is.

Now how particularly serviceable the strong Muscular Fibres B (*Tab.* I. *Fig.* 5.) are thereto, is plain, *first*, because they encompassing the Left Orifice of the Stomach I, do shut the same exactly at the Time when the Food is thrust out at the other Orifice K, to the End that the Chyle may not be driven back again into the Throat thro' the Orifice I P. *Secondly*, Because these Fibres B running length-wise, are inserted in the right Passage of the Stomach K, which when they become shorter, they draw towards themselves, and by this one Action do at the same time contract or shorten the Stomach, from M to N, and whilst they shut one Orifice I, they do in some manner dilate the other K; insomuch, that it is impossible, when all these Fibres are contracted and perform their Function, but that the Chyle should be protruded by the Orifice K K.

How comes it to pass now, if all this be done by Chance, that these Fibres of the Stomach run, or are extended so differently from those of the Throat, and those of the Bowels, which shall be accounted for hereafter? And whence comes it, that each of them is adapted, in the most proper manner, to its right Use, and the Functions that are required of it? Can the wonderful Structure of the Fibres be deemed accidental? Why don't they say the same of the Preparation of the Ropes that are used in the drawing up of a *Rammer*, in which, comparatively, there is very little Art.

Sect. VIII. *The Mucilage, or Slime, of the Stomach.*

Besides all this, there is often a Necessity in some Persons, for an Acid Matter to compleat the Dissolution of some kinds of Food; of which Nature are also several Medicines, such as Vinegar, Verjuice, Lemon-Liquor, Mustard, Pepper, Root, and almost all Spices, all Salts, as well the Common as Volatile, and others, which are all acid, and nevertheless very necessary on some Occasions. Now, forasmuch as the Stomach is membranous, and the Membranes thereof extreamly sensible, there was danger, that by such sharp Matters, it might either be affected with Pain, or else irritated to Vomiting or other irregular Motions: Can we therefore here, without Thankfulness and Astonishment too, observe how it has pleased our Gracious Creator, with great Wisdom to provide against the same, by cloathing the innermost Part of the Stomach and Bowels with a thick and tough Slime, (where-

by

by they are defended from the Corrosion of those sharp Matters) which is stopt there, and adheres to small Fibres, that stand streight up on the sides of the Stomach, like the Silk Thread in Velvet, to prevent the said Slime from being carried away immediately by the Food that passes through the Stomach.

Can any Body now, considering what has been here said about the Stomach, (tho' for Brevity sake I have designedly omitted several remarkable Circumstances) remain unconvinc'd, that it was a Great Creator who, in order to display his Wisdom and Goodness to Mankind, has produc'd all this in such a beautiful Order? And can he, without Scruple, ascribe this whole Structure to Ignorant Causes; the rather, because any one of these Circumstances failing, very dismal Consequences, and even Death it self, would sometimes follow.

Sect. IX. *Of Hunger.*

To say nothing more about the Stomach, which seems plainly to prove the Design of Him that made it; are we not particularly obliged to return him our Thanks for having been pleased, over and above, to add to the Structure of the Stomach, besides so many other necessary Uses, the following Property, *viz. Hunger*, by feeling which, we are acquainted, that we stand in need of new Food and Refreshment, of which, without such a Warning, we should not be sensible oftentimes, till we become weak and faint, and unfit for Business for want of the same?

He must be miserably blind who cannot discover a Wise and Gracious Maker of all these things; or that can perswade himself, that their skilful Structure and so many Conveniencies and regular and well adapted Uses, can be produced by meer Chance or irrational Causes.

Sect. X. *The Uses of the Guts.*

Let us now pass on with the Food to the Bowels or *Guts*; to know the Construction of which, you may consider the Tube (*Tab.* I. *Fig.* 2.) representing the Gullet and the Stomach as Parts of the Bowels to which they are annex'd, since the Membranes and Tunicks thereof are for the most part analogous with those of the Guts, and so are its Motions too, by which the Matter contained therein is protruded; for which reason we shall not repeat the same here.

This Tube has the following great Uses; (*Fig.* 1.) First, that it separates that which is proper for Nourishment from the unnecessary Parts, conveying it to the *Venæ Lacteæ*, or Milky Veins: Secondly, that it carries the Remainder of the Food to the *Intestinum Rectum*, in order to be there discharged.

Now to speak of this last in the first place, it will not be necessary to say, after the Description of the Gullet and Stomach, that this is also performed both by the long and circular Fibres; which do likewise here produce, by contracting and shortning themselves, a Protrusive Motion, which is called by the Anatomists, *The Peristaltic Motion.*

Sect. XI. *The Meſentery.*

You may ſee how theſe Bowels are placed in the Body, in *Tab.* I. *Fig.* 3. Now in caſe this Tube of the Bowels was ſhort, there would be danger that the Chyle, or Nouriſhing Juice, extracted from the Food, might in a great meaſure be diſcharged with the uſeleſs Part thereof. Is it therefore without a Deſign of the Maker, that there are ſo many Meanders or Windings therein; ſo that it is very near ſix times the Length of a Man? And particularly, that notwithſtanding all its Turnings, it is faſten'd in ſuch a manner to the *Meſentery*, that it is not poſſible for the Food, either to miſtake its way, by reaſon of the length of the Inteſtines, or to take any ſuch Turn, as that the Way thro' which the Chyle paſſes ſhould be ſtopt; as may be ſeen in *Tab.* I. *Fib.* 6. where G G repreſents the Meſentery, and L L the Bowels or Guts faſten'd to it, but both extended.

Now can any one ſee without Aſtoniſhment, that in this Membrane (which being only flat and round, would be too big to lie conveniently in the Belly, in caſe it ſhould be faſten'd to ſuch a great Length of the Bowels in its Circumference) ſuch a wonderful Method is uſed by our moſt wiſe Creator for that purpoſe, *viz.* by pleating it upwards and downwards upon the Edge of the Meſentery, juſt as they uſed to do the Ruffs in old Times? An Inſtance of which may be ſeen in that Part of the Inteſtines, deſcribed by P Q, R S, (*Tab.* I. *Fig.* 6.) and more fully in the 2 *Fig.* of the 18 *Tab.* of *Verheyen*, in the ruffled Edge B B, of this expanded Meſentery; to which, that we may not multiply the Figures too much, we refer thoſe that are deſirous to ſee it in its true State. It is by this means, that tho' the ſame is not above two Spans Breadth in a Man of a middle Size, yet by theſe Pleats and Folds it acquires ſo much Length, as to afford ſufficient room for the Tube of the Inteſtines, which is ſo much longer, to be faſten'd to it. Now, in caſe this Problem had been laid before a great and able Mathematician, would not he have thought that he had acquired no ſmall Honour, by ſolving it after this Manner? And can any Body fancy that this is performed by Chance, or without Wiſdom?

Sect. XII. *The Glands of the Inteſtines.*

Now whilſt the Nutricious Juices are continually ſeparated from the Food in the Bowels, and by Openings, which are found in their Membranes, paſs into the External Parts, as we ſhall ſhew hereafter; it ſeems as if it could not be avoided, that the Remainder being thereby become dryer, ſhould be hinder'd from proceeding conveniently on its way in this Tube: To remove this Difficulty, the adorable Creator has been pleaſed to place ſeveral Glands in the Inteſtines, from whence they filtrate a Liquor ſufficient to ſoften the Excrements, beſides others proceeding out of the Glandulous Coat of the Bowels themſelves, which help to render the Paſſage ſmooth and ſlippery, and ſo fit for the intended Service.

Can this likewiſe be ſaid to be done by Chance? Why then are theſe Glands ſmaller and fewer in the thin Guts G, H H, I I, (*Tab.* I. *Fig.* 3.) which

which lie next to the Stomach, where that which is in it has a great deal of Chyle and Moiſture? And why are thoſe Glands multiplied about the End of theſe thin Guts, unleſs it were that the uſeleſs Matter, being by the Separation of the Chyle grown dryer, wants more Moiſture to render it ſo fluid; and to the End, that what ſtill remain'd in it of the Chyle, may be ſqueez'd out of it; after the Manner of the Apothecaries, who, in order to extract the Juices from their Druggs when they are pretty dry, put ſome Liquor in while they are pounding them? Laſtly, Why are thoſe Glands in the thick Guts, M, N N N, O, that lie fartheſt from the Stomach, and where the Matter to be diſcharged is in a manner diveſted of all its Chylous Juice, the biggeſt of all; unleſs it be, that the greateſt Moiſture is there requiſite to prevent its being too hard?

SECT. XIII. *The Wrinkles, Valves, and* Inteſtinum Rectum.

NOW, not to mention the Wrinkles of the thin Guts; the uſe of which is to hinder the digeſted Food, that has ſtill ſome Chyle in it, from paſſing too ſwiftly thro' thoſe Orifices that are made to receive the Chyle, nor the great *Valve* K, at the end of thoſe thin Guts, whereby the Matter, that is hardly now of any further Uſe, is hindred from going back: Why are the thick Inteſtines larger, and furniſhed with ſo many ſeparated Places; unleſs it be to collect the uſeleſs Matter therein, and to the End, that People may not be too frequently obliged to diſcharge the ſame?

Is it not therefore very plain, that the *Inteſtinum Rectum* O P, is only contrived for diſcharging the aboveſaid Matter? Why does it deſcend ſtreight forwards, unleſs it were, that the Diſcharge of the ſaid Matter ſhould not be obſtructed by unneceſſary Windings and Turnings?

Is all this made without ſuch a Deſign? Why is there a round contracting Muſcle P, which, like a Ring, pinches this Bowel at the end of it? Is it not to hinder an inceſſant Protruſion of the Excrementitious Parts, by the continual Periſtaltic Motion of the Inteſtines? And ſince that in ſeveral Diſcharges, when the Matter is hard, the *Inteſtinum Rectum* O P, is preſſed and ſinks downwards, we may ſee that the two Muſcles, Q P, and Q P, are placed there on purpoſe to ſecure it; for by their Aſſiſtance, the ſhutting Muſcle and the *Inteſtinum Rectum* are drawn back again after a difficult Diſcharge, and made to aſcend by the ſhortning their Fibres.

SECT. XIV. *The Uſes of the Oblique and Lateral Muſcles of the Belly.*

AND foraſmuch as the Protruſive Motion of the Bowels is not ſometimes ſtrong enough alone to diſcharge the Excrementitious Matter; ought we not likewiſe herein to adore the exceeding great Wiſdom of the Creator, who, beſides the *Diaphragm* and Meſentery, has after ſo wonderful a Manner made the whole Covering, or Tegument of the Belly, to be aſſiſting thereto; by which Means the Expulſive Force may be render'd incomparably greater, as often as there is any occaſion for it?

In order thereto, People are wont, firſt, ſtrongly to draw in their Breath; by doing of which the Midriff lying juſt above the Stomach, ſo violently

preſſes upon all the Bowels, that unleſs they oppoſe it on purpoſe, the whole Belly riſeth therewith, to the End, that the Guts may be preſſed more cloſely together.

Now ſince the Bowels, thus preſs'd down by the Midriff, are forc'd to dilate themſelves outwardly in the Belly; unleſs the extended Covering of the Belly did again contract it ſelf by the Action of its Muſcles, and preſs the Bowels together with a ſtrong Force, the Excrements cou'd not be protruded thro' the *Inteſtinum Rectum*: But ſince that Inteſtine is open, and at the ſame time the Bowels are preſs'd together from all Parts; the Matter contain'd in them, muſt be protruded thro' the Orifice of the ſaid *Rectum*.

Now, how wonderfully this Comprehenſive Force is produced by the Muſcles which compoſe the Coverings of the Belly, is plain to thoſe that are acquainted with the Structure thereof.

To give you ſome Notion of it here, with only mentioning the uſual Coverings which the Belly has in common with many other Parts; (*Tab* II. *Fig.* 1.) A is the *Cuticula* or upper Skin, B the *Cutis* or Skin, C the Fat, D the fleſhly Tegument or Covering; the External Parts thereof do conſiſt, on both ſides, *firſt*, of the Muſcle G, the Fibres of which deſcend obliquely from the *Vertebræ* of the Loyns to the *Linea Alba* K K, which runs downwards from the Breaſt-bone through the Navel L, to the *Os Pubis*, and is of a Strong and Fibrous Structure, in order to reſiſt the Force of the Muſcles drawing againſt one another on each ſide: The Muſcle of the ſame Name and Kind belonging to the other ſide, is laid open at O, in order to ſhew that which is under it. *Secondly*, we ſee another Pair of Muſcles lying under the former, the Fibres of which running upwards obliquely from the *Vertebræ* to the aforeſaid *Linea Alba* K K, do croſs thoſe of the firſt Muſcle; as appears here at M, on the one ſide, under a part of the firſt Muſcle, which is turned up; and on the other ſide, at P, where it is fully ſeparated. *Thirdly*, There are a Pair of Muſcles that lye underneath the ſame, on the right ſide at U, the Fibres of which are extended laterally or croſs, and not obliquely, from the *Vertebræ* to the *Linea Alba*, or White-line K K: The tranſverſe Muſcle of the left Side is not viſible in this Figure, becauſe of the Muſcles that lie upon it, called the *Lateral*

Let us now ſuppoſe, that theſe two loweſt Lateral Muſcles V, do encompaſs the Belly quite round, and in that manner compoſe a Cavity, which contains the Bowels; and further, that all the Fibres of which they are made up, are ſhorten'd or contracted: It is plain, that the Cavity has thereby a leſſer Circumference, and conſequently muſt be narrower; and ſo the Bowels therein contain'd will be preſſed together on all ſides.

But ſince thoſe Muſcles are not only ſerviceable in the Evacuation of the Bowels, but likewiſe of the Bladder, and even in the Labour of Child-bearing Women, to whom they are of the greateſt Uſe in that important Caſe; it was neceſſary that this Preſſure ſhould be performed with very great Force; for which reaſon the Wiſe Creator has placed another Pair of Muſcles (one of which is repreſented by M) upon the *Lateral*, the Fibres of which running obliquely upwards, as is ſaid before, and ending in the *Linea Alba* K K,

when they operate and become ſhorter, do in like manner ſtraiten the Belly; but they do alſo at the ſame time (as is well known to the Mathematicians) by their Obliquity extended upwards, as it were, draw down the whole *Linea Alba* K K. Now to obviate the Inconveniencies that might proceed from hence, the Fibres of the Muſcles G, that lie upon theſe, do run with a quite contrary Obliquity downwards; whereby the Belly is not only ſtraightened with a new Force, but the *Linea Alba* K K, is again drawn upwards by this contrary Obliquity.

Sect. XV. *The Uſe of the Pyramidal Muſcles.*

Now if each Pair of theſe laſt oblique Muſcles operated with like Force upon the *Linea Alba*, and that the ſame was drawn as much upwards by one Pair as downwards by the other, they would balance one another; and this White-line K K, would remain in its Place, without moving one way or the other: But ſince theſe laſt and outmoſt deſcending Muſcles G, are much larger and ſtronger than thoſe that lie under at M, it muſt follow, that whilſt they operate together to diſcharge the Belly, by this over-balance of Force, theſe Fibres or White-lines K K, will be conſtantly drawn ſomething upwards.

Can it now be brought about by Chance, that we meet with a Pair of Muſcles S and T, under the *Os Pubis* (the laſt of which, T, is ſhewn ſeparated, and hanging downwards out of its Place) which, from the Figure of them, are called *Pyramidal*, and whereof the Fibres do only run upwards along the White-lines to K, or about as high as the Navel; ſo that it is very plain to every Body, that being ſhorter at S, and conſequently their Fibres being drawn downwards, the *Linea Alba*, to which the Fibres are faſten'd, muſt likewiſe follow downwards; and therefore theſe *Pyramidal* Muſcles ſeem to be made uſe of as a Balance of the Force, by which the deſcending Oblique Muſcles at G, do exceed the aſcending Oblique ones at M; and whereby, if not prevented by the *Pyramidal*, the *Linea Alba* would otherwiſe be mov'd upwards? This Opinion is confirmed; foraſmuch as in many Bodies there are found but one of theſe *Pyramidal* Muſcles, and not always juſt two, ſince one that is big enough can anſwer the aforeſaid Uſes: Nor yet are the ſame neceſſary, when the aſcending and deſcending Oblique Muſcles are of equal Strength, as has been ſometimes obſerved.

Sect. XVI. *The Uſe of the Right Muſcles.*

But beſides all this, there ſeems ſtill to remain the following Inconveniency; that the Belly being ſtreighten'd by theſe Muſcles with ſo great Force only Side-ways, the Inteſtines would hereby be preſſed as much upwards as downwards, and would likewiſe be driven with too great Violence upwards againſt the Midriff; ſo that the flexible Structure of the Cartilages would be raiſed upwards, by which Means the Protruſive Faculty would be weaken'd. To prevent which, and that nothing ſhould be deficient in this great Work, the Wiſdom of the Sovereign Creator ſeems to have faſten'd two other Muſcles, Q Q Q, called the *Right* to the *Os Pubis*

at S, after such a manner, that their other Extremities, Y Y, should be fasten'd to and about the Breast-bone; whereby these being contracted, or made shorter in their Fibres, draw the Ribs, with their Cartilages (which terminate in the Breast-bone) downwards; and so they do not only hold fast to the Places to which the Midriff is fixt, but likewise hinder the same from bending upwards by the strong Pressure of the Bowels against the Midriff, when those Bowels are thrust upwards and downwards by the aforesaid Annular Muscles of the Belly.

There are likewise seen in the Right Muscles Q Q Q, three or four *Lateral* white Fibres, R R R; which do most commonly divide each Right Muscle into four other, following one another, to the End, that these Muscles may perform their Function by a lesser Contraction, and proportionably by a lesser Tumifaction, and so not take up too much room; which otherwise, in case the Fleshly Fibres of the *Os Pubis* should extend themselves to the Breast-bone, would not be perform'd so regularly or conveniently.

The other Uses which are ascribed by the Anatomists to these *Right* and *Pyramidal* Muscles, may be seen and consider'd by every one in their Writings; we have dwelt long enough upon them here already.

Sect. XVII. *Orifices in the Muscles for the Seminal Vessels.*

He that is not satisfied, that all these things are performed for Wise Purposes, let him cast his Eyes farther in *Tab.* II. *Fig.* 1. upon the Orifices described by the Letter I, as they are found in the three Muscles; thro' which, at the Groin, there goes the Tube W, thro' which the Seminal Vessels in the Males, and the round Ligaments of the Matrix in the Females do pass; and consider whether such necessary things as these are placed there by Chance.

Sect. XVIII. *The Voluntary and Spontaneous Motions of the* Intestinum Rectum.

To add something more to what has been said above, and which seems to me sufficient not only to settle a Sceptical Mind, but even to convince an Obstinate Atheist; let both these unhappy Men seriously consider, that in this great Length of the Tube of the Bowels, which is continued from the Stomach to the *Intestinum Rectum*, no Body can encrease or diminish the Contractions or Wringings of the same; insomuch, that all those Motions (whereby that which is in the Bowels is protruded and discharged) are quite out of the Power of his Will; but if the same should have place likewise in the lowest Part of the *Intestinum Rectum*, Mankind could never have any command over their Natural Evacuations, in order to retain or discharge them, as occasion should require. And can a Man yet doubt, whether there be a God that has wisely and graciously order'd all these things, when he perceives, that in the whole Structure of the Bowels, it is the *Intestinum Rectum* only, into which Nerves are derived from the *Medulla Spinalis*, or Marrow of the Back-bone; yea, that the Motion of that Bowel alone is subject to our Will, for the Prevention of so many Inconveniencies, which it would otherwise be impossible to avoid?

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Fig. 2

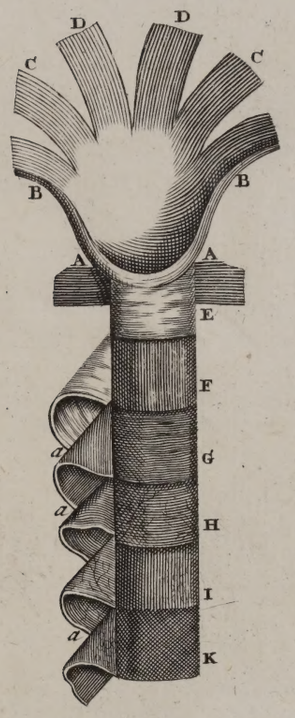
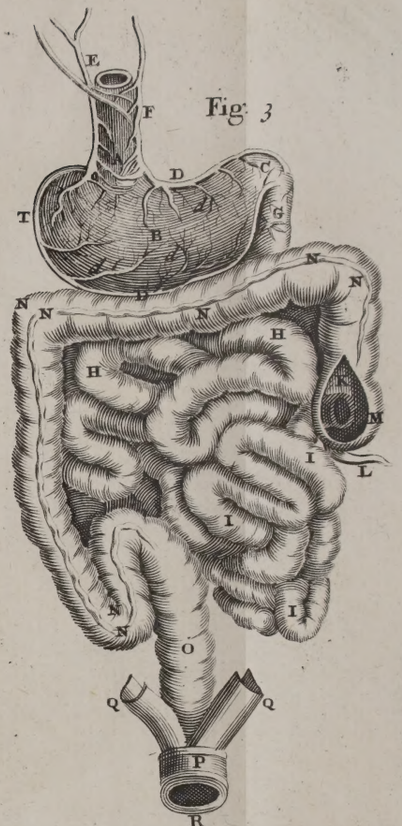


Fig. 3



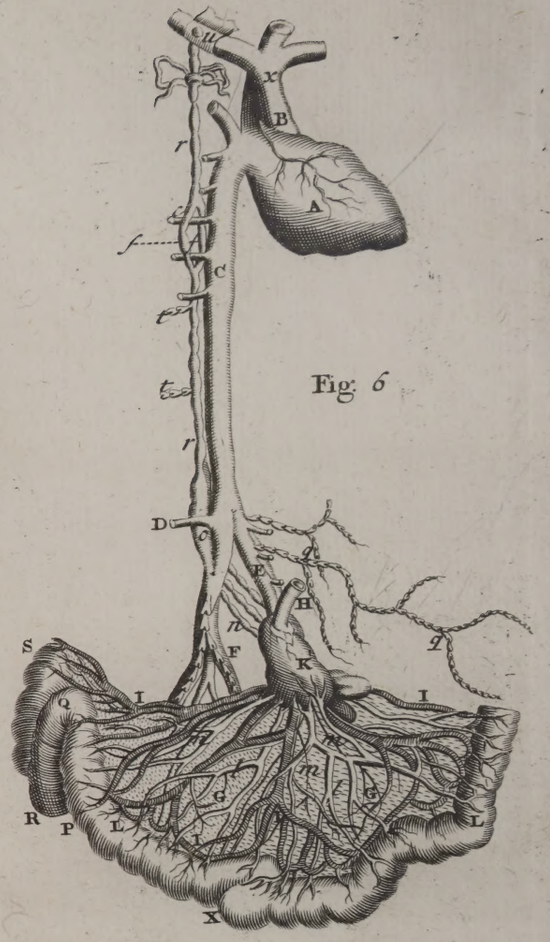


Fig. 6

Fig. 4

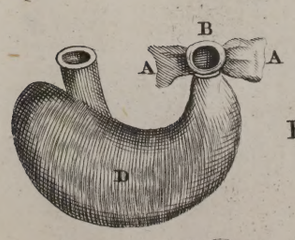


Fig. 5

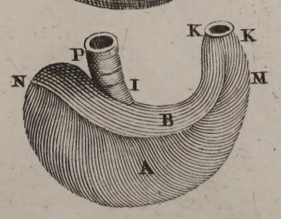
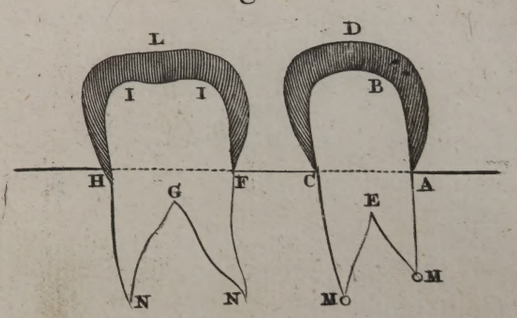
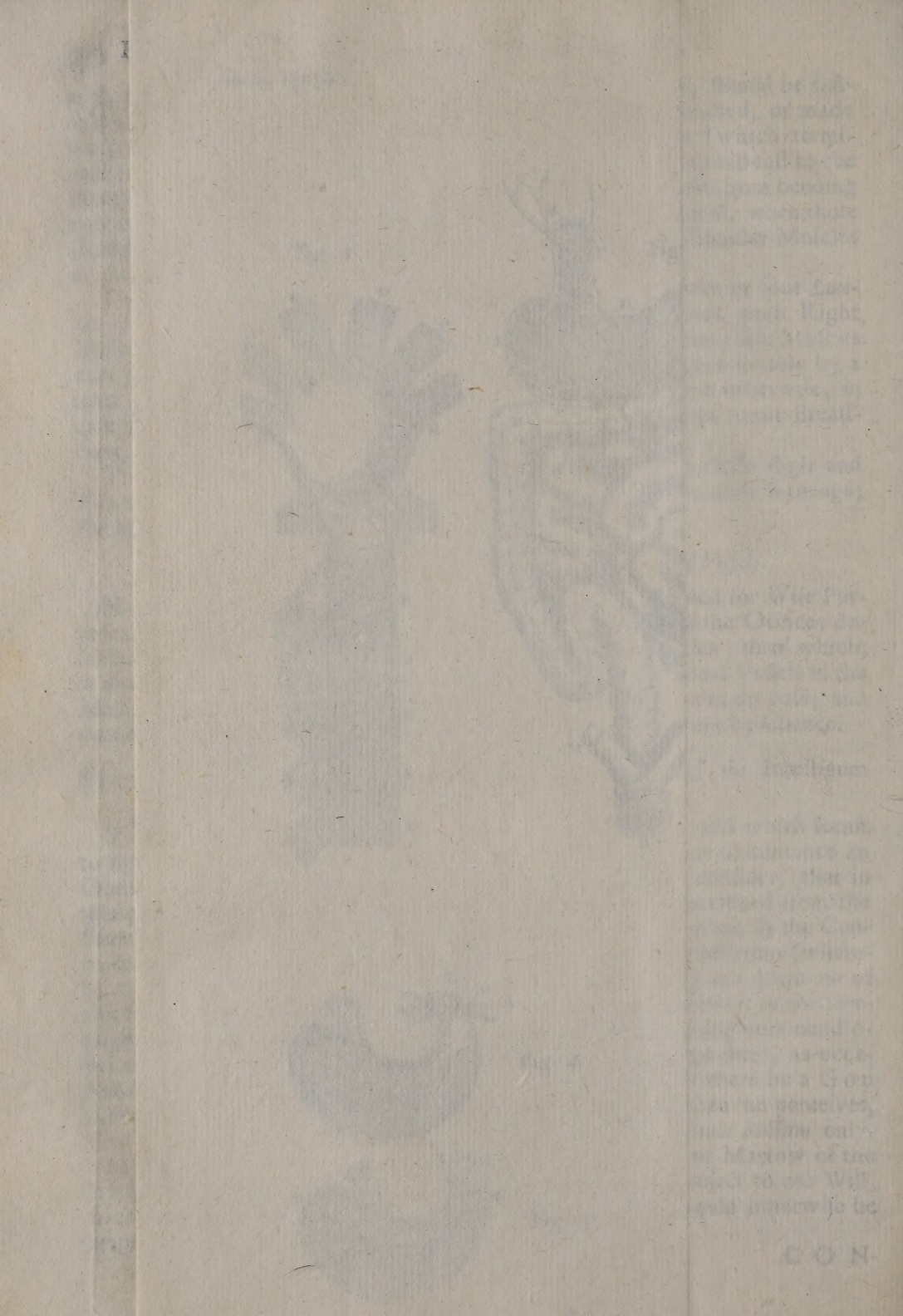


Fig. 1





CONTEMPLATION V.

Of the Venæ Lacteæ, *and* Ductus Chylicus.

Section I. *The Transition.*

AFTER having traced the greatest part of the Food as low as we could, let us now turn back again to the Stomach, in order to observe the Ways and Passages by which our merciful Preserver has been pleased to conduct the Chyle or Nourishment that is extracted for our Food, in order to prepare and render it more useful for making good what is wasted in our Bodies.

Not to mention in this Place the curious and skilful Structure of the *Gall-Bladder*, and the Vessels, which coming out of that, and of the *Liver*, do continually introduce a great quantity of *Gall* into the *Duodenum*, where it mixes it self with the Food that is sent thither thro' the *Pylorus* from the Stomach; but more particularly, as often as by the drawing in the Breath, the Midriff descending, presses upon the Liver, and thereby squeezing the Gall-Bladder (which lies within the Liver) forces out the Gall through a Vessel that reaches from its Bladder to the Intestines. To say nothing here of that Liquor that proceeds from the *Pancreas* or Sweetbread (a great Gland lying under the Stomach) which mingles itself with the extruded Gall, about four or five Fingers below the *Pylorus*, or lower Orifice of the Stomach, and mostly by the same Passage. Not to enter here upon enquiring into the Uses of both these; whether, for instance, they serve together to separate the Chyle from the grosser Parts of the Food; or to preserve the same from Corruption, by the Bitterness of the Gall; or to render it more Fluid, or to incorporate those Parts of it, which cannot otherwise be easily mixed, such as the fat and watry Parts; or to qualifie the Bitterness of some, by the others; or, for any other Purposes, which, by a more nice Enquiry into the Nature of them, are daily discover'd: But seeing that the determinate Use of each of these has not yet been decided, we shall confine our selves to those things only, from which we can draw such undoubted Conclusions, as are more than sufficient to prove abundantly the Perfections of our Maker.

Sect. II. *The* Venæ Lacteæ *and* Receptaculum Chyli *in a Dog.*

To proceed then; If there were no Lateral Orifices or Openings in the Membranes of the Duct of the Intestines, (as there are none in the Throat, for instance, and Stomach) the Chyle or Juice, which becoming Blood, sustains the Body, would be discharged at the same time, together with the grosser

grosser Parts that pass thro' them; and Mankind would consume away and die for want of Nourishment: Can it therefore be thought, that this likewise is meerly Accidental, that in order to prevent the same, there lies in the Mesentery G G, (*Tab.* I. *Fig.* 6.) besides the Blood Vessels I I, and the Nerves *m m m*, which pass thro' it, another kind of very narrow Vessels *l l*, which, when a Creature has continued long without eating, are quite invisible, but if you dissect them a few Hours after it has been fed, they appear as little Veins full of a white Matter like Milk; from whence it is also, that they take the Name of *Milky Veins* (*Venæ Lacteæ*;) these little Tubes open into the Intestines L L, which by their Contracting and Protrusive Motions, do squeeze out the thinnest of the Food, or prepared Chyle, in these Milky Veins, under the Form of a White Substance; which (in Dogs, according to this Figure borrowed from *Verheyen*) takes its way, first towards a great Gland K; but in Men, by several other smaller Glands; since, according to the said *Verheyen*, this great Gland is not found in them? Those that desire to see the Description of the Mesentery in a Man, may be pleas'd to consult the 18*th Table* of the said Author, where the Glands are represented by the Letters *a a* in the 2*d Fig.*

We shall say nothing of these Glands, because Anatomists are not as yet entirely agreed about the Use of them; only 'tis known that this Chyle is discharged into a large Receptacle O, by the *Venæ Lacteæ* (*Tab.* I. *Fig.* 6.) coming from this Gland: The Anatomists call it *Receptaculum Chyli*, or *Cisterna.*

Sect. III. *The Receptacle of the Chyle in Humane Creatures.*

It must be remembred, that in this Figure the Course of the Vessels is represented as it appeared in Dogs, forasmuch as they are seldom to be shewn in Men, who cannot be so soon open'd after their Death. However, they that desire to see a true Description of these Parts, as they lie in Humane Bodies, may find them in the *Leipsick Transactions*, *p.* 57. *Anno* 1699. extracted from an *English* Book of *W. Cooper*, consisting particularly in the following Differences: 1. That the great Receptacle of the Chyle, represented here by the Letter O, is composed in Men of three large Tubes and Parts. 2. That the Links of the Chains that are here described at S, (in the Tube O *s*, which runs upwards, and is called the *Ductus Chylicus*, or *Thoracicus*,) are observed to be more numerous or various in Men. *Rohault* does likewise make mention of one that is found in a Man.

Sect. IV. *The Course of the Chyle to the Heart.*

To return: In this Receptacle O, the afore-mention'd Food mixes itself with another Humour, Water, or Whey, which the Anatomists call the *Lymph*; and which having performed its Service to the Body, is continually derived this Way by the *Vasa Lymphatica*, or *Lymphaducts* or *Lymphatics*; and then this *Chyle* and *Lymph* pursue their Way together upwards thro' the Belly and Breast along the Back-Bone, from the Receptacle of the Chyle O, thro' the

the *Ductus Chyliferus r r*; and finally are discharged at *u*, in the *Vena Subclavia u x*.

The Blood running from *u* to *x* in the said *Subclavia*, goes from thence thro' *x* B, called the *Vena Cava*, or Hollow Vein, to the Heart A; from whence the *Chyle* and *Lymph* being mingled with the Blood in *u*, are carried round with its Stream throughout the whole Body, in order to the Nourishment thereof.

Now can any one suppose, that the Structure and Disposition of so many Vessels, such as the *Venæ Lacteæ l l*, the *Receptaculum Chyli* O, and its *Ductus r r*, are produced by Chance? Can it be without Design, that the *Vasa Lymphatica q q* and *t t*, do discharge themselves in the two last mentioned Receptacle and Duct, to make a perpetual Stream in order to convey the Chyle with greater Conveniency to the Blood in the Vein *u x*? Of all which, if any thing fails or is deficient, a Man runs the Risque of losing his precious Life. Is it without Wisdom that the Creator is pleased to divide the Receptacle of the Chyle O, into three Tubes in Men, which in Dogs and other Creatures is but one large one? To the end that in Men, who walk erect, the great Quantity of the Liquor should not easily burst the Membrane that composes the Receptacle O, and which is unconceivably thin and fine.

If all this be not yet sufficient to convince any one, let him attend to that which follows concerning the *Valves*, which will lead him as it were by the Hand to an Almighty and All-wise Creator.

Sect. V. *The Valves in the* Ductus Chyliferus, Venæ Lacteæ, *and* Vasa Lymphatica.

Can we not again visibly observe a fix'd Purpose and Design of bringing the Chyle to the Blood and Heart? Which otherwise, together with the *Lymph* in the *Ductus Chyliferus r r*, (*Tab.* I. *Fig.* 6.) ought naturally to descend, by reason of the erect Posture of Men: To prevent which, it is most wonderfully provided by the Great Creator, that there should be *Valves* in the said Tube or *Ductus*, which are opened by the Chyle when it proceeds upwards from O to *u*, and so takes its right Course, but are shut by the same, if it should attempt to go backwards and descend; just as we see in the Gates of Sluices, which, as the Water comes one Way, are open'd without Trouble, but shut of themselves on the other Side, by the Flux of Water against them.

And there being a Danger that the Liquor in the *Venæ Lacteæ l l*, and in the *Lymphatic q q*, should descend and go backwards by its own Weight, the like kind of Sluices or Flood-Gates are placed in both of 'em.

Among the Lymphatic Vessels, the *Ductus Chyliferus* itself, *r r*, must be reckoned, since it is likewise continually full of this Water, or *Lymph*, when there is no Chyle mingled with it; and since, as we have said before, it has also its Valves, the Figure of which may be seen in some measure in *Tab.* II. *Fig.* 2. at *c c* and *c c*, and which are in like manner opened by the Liquor that runs from *a* to *d*: But if the same Liquor should run backwards from *d* to *a*, they would be closed thereby.

Sect.

Sect. VI. *The Protrusion of the Chyle.*

Now if it be further observed, that this Vessel is exceeding tender, for which reason it is likewise guarded by the *Pleura*, or Membrane of the Ribs; that it has no sufficient Fibres for protruding the Liquor contained in it when necessary (which Fibres do for this Purpose abound in the Intestines and Arteries) but that nevertheless the Process of this Liquor is so necessary towards the Preservation of our Lives, that they could not continue without it; ought we not again to stand amazed at the Wisdom of the great Creator, who in this Case has been pleased to use a singular Method to drive this Liquor upwards, causing for that Purpose the great Artery C, (*Tab.* I. *Fig.* 6) to run along the same; placing the *Intercostalis c c c*, as also the Artery of the Reins D, above and across the same, which swelling at every Pulse of the intruded Blood, do as often press upon this Tube; and the Liquor thereof being hindered by the Valves from going backwards, must necessarily move forwards and upwards; to which likewise the Tendons of the Midriff, which are drawn up in Breathing, and which also press upon this Tube, do seem very much to contribute?

Is it not now very plain, the Motion being performed after this manner, how necessary these Valves are; since without 'em the Pressure might as well force the Liquor downwards as upwards? It does likewise appear, why they are placed so close to each other, and are more numerous here than in the Veins, *viz.* That the Liquor should be immediately stopp'd as it endeavours to return; whereas otherwise, if the Tube between the two Valves should be very long, it might cause it to swell so much, by reason of its Tenderness and Length, that there would be not only a Danger of bursting, but the Motion or Course of the Liquor would likewise become too slow.

Sect. VII. *The Valve in the* Vena Subclavia.

Here is yet another Instance of the wonderful Wisdom of Divine Providence, tho' it seems to be but a small Matter; namely, that this *Ductus Chiliferus r r*, discharging its Liquor at *u*, into the Subclavian Vein *x*, is covered at its Orifice with a little Membranous Valve in the Shape of a Half-Moon; which does hinder, in the first place, the Blood from descending from the Vein *u x* into this *Ductus Thoracicus r r*, and secondly, is the Cause that this little Membrane, being only open exactly on the Side *x*, the Way that the Blood runs, the Chyle coming out of it is thereby immediately carried along with the Stream thereof; whereas, if it had been open on the other Side, the Blood by its strong Circulation would press into this Vessel *r r*, and so hindering the Chyle from going forwards, would put an end to our Life.

I cannot forbear representing this last Matter in *Tab.* II. *Fib.* 2. which is borrowed from the Accurate Dr. *Lower*: *d b* and *c a* is the *Ductus Chyliferus*, *c c* the Valves, which are here more visible, because the Chyle being squeezed backwards with the Finger from *d* to *b*, against the said Valves, makes the Tube swell in that Part, leaving the other *b d h* empty. But that which

is

is most remarkable in this Figure, is the little Semi-lunar Valve *i*, which covers the Orifice *h* of the *Ductus Chyliferus* in the *Vena Subclavia*, after such a manner, that the Blood flowing from *f* to *g*, and so on to the Heart, is hinder'd from forcing its Way into the Chyle-Vessel *d a*, and yet admits of a free Passage for the Chyle and *Lymph*, as they run from *a* to *b*: *e* is the Jugular Vein, the Blood of which descending into the Vein *f g*, renders this little Valve *i* so much the more necessary.

SECT. VIII. *Convictions from the foregoing Observations.*

Is there then occasion for any farther Proof of the adoreable Wisdom of the Creator, than what has been just now produced? And can any Man be so far mistaken as to attribute all this to Chance, or ignorant Causes? For if each of these Things were not made for that very End of carrying the Chyle and *Lymph* up to the Blood, and thereby preserving the Life of a Man, why are the little Valves placed there? Why are they all open on the same Side? Insomuch, that if among the great Number of them any one should fail in performing its Work, there would presently be an End of Life. Once again; If any one supposes that all this depends upon Chance, why does he not think the same of the Sluice-Gates for Water-Mills or other Uses? For I cannot believe that any one would dare to affirm the same of a common Sluice (which nevertheless has only the Structure of but two of these Valves) that it was made without Knowledge or Skill; to say nothing of the amazing Structure of such an innumerable Company of Sluices following one another, and adapted to one and the same Purpose, as in the Case of these Tubes.

After all this, if a Man seriously reflects, that upon the Structure of so tender a Vessel as the *Ductus Chyliferus a d*, (*Tab.* II. *Fig.* 2.) upon the Disorder of so small and not less tender Valves *c c*; upon the Inflection towards the wrong Side of these Valves, which are composed only of a thin, moist and flabby little Membrane; especially upon such a little worthless Instrument as the Valve *i* appears to be (which covers the Orifice *h* of the *Ductus Chyliferus*, where it is inserted in the Vein *f g*;) and lastly, upon the Disorder not only of all these together, but of any one of these so small and seemingly contemptible Particles, our precious Lives are entirely depending; and if but one of 'em all should fail to perform its Function, so valuable a Creature as Man is, would presently turn to a putrifying Carcass: Must not every one confess, that *he is formed after a most fearful and wonderful Manner?* And ought we not daily to worship our Great Preserver with the most grateful Acknowledgments, for his having vouchsafed to preserve such fine and such delicate Parts of the Body, all of them absolutely necessary to Life, so long and in so good a State and Condition? So that the *Psalmist* of *Israel* had great Cause to say, *Psal.* cxxxix. *v.* 14. *I will praise thee, for I am fearfully and wonderfully made; marvellous are thy Works, and that my Soul knoweth right well.*

How often do Clocks, Mills, and other moving Machines stand in need of being adjusted by a skilful Master? And ought not this to teach every

one, that a great Director does ſupport and maintain all theſe Things in that neceſſary State, towards which all Creatures, all the moſt skilful Phyſicians, all the moſt learned Philoſophers, or the moſt ingenious Artificers, cannot contribute the leaſt in the World? And how can any Man forbear charging himſelf with the utmoſt Unreaſonableneſs, who ſeeing ſo great and important a Work, as is the Life of Men, and all other Creatures, carried on by ſo ſimple, and, in Appearance, contemptible Means, does nevertheleſs perſiſt in aſcribing it all to meer Chance, or ignorant Cauſes? And being ſenſible how much Good is thereby daily produced in himſelf, (concerning which he is forced to own, that he not only gave no Direction, but, which is more, that he had not the leaſt Perception;) muſt he not pronounce himſelf both ungrateful and worthy of Condemnation, as often as he refuſes to acknowledge the Mercy and Goodneſs of his Benefactor, and even his Wiſdom alſo, in the midſt of ſo many Wonders.

CONTEMPLATION VI.

Of the Heart.

Sect. I. *The General Uſe of the Heart.*

LET us now go on, and trace the Chyle or Food (which, as we have juſt now ſhew'd, is mingled with the Blood at the left Subclavian) quite to the Heart; in the Structure of which there do occur ſo many wonderful Things, that one would imagine that none but a very unhappy or obſtinate Perſon, ſeeing and comprehending the Compoſition of this Organ, could help being convinced of the Wiſdom of the Great Creator, and of the determinate End to which it is adapted, *viz.* the Reception and Expulſion of the Blood, (whether there be other Uſes of the Heart, I ſhall not here enquire) to the end, that the Blood, by this Motion, having perfected its Circulation thro' the Lungs, and thro' other Veſſels, to all the Parts of the Body, and performed ſeveral other Functions in other Places, might return to the Beginning of its Courſe, that is, to the Heart and Lungs.

Sect. II. *The Deſcription of the Heart.*

THIS Heart has two Cavities, or Ventricles, ſeparated from each other by a thick fleſhy Wall, or *Septum*, which every one may ſee, that will take the trouble to cut acroſs the Heart of an Ox or Sheep. The Heart, at the upper Part of it A, (*Tab.* II. *Fig.* 3.) is thick, but at the lower Part B, much ſlenderer; the Shape of it is like that of an inverted blunt Pyramid;

it

it is faſtened, and hangs by its Veins and Arteries E F G H I; E is the *Vena Cava*, or hollow Vein by which the Blood deſcends; G is the *Vena Arterioſa*, or *Arteria Pulmonaria*, (the Pulmonic Artery) thro' which it paſſes out of this Ventricle into the Lungs; and H is the *Arteria Venoſa*, or *Vena Pulmonaria* (the Pulmonic Vein) thro' which the ſame Blood returns from the Lungs into the left Ventricle of the Heart; out of which it is carried by the *Aorta*, or great Artery I, to all the Parts of the Body; C is the Right Auricle of the Heart, into which the Blood paſſes from E and F, before it falls into the Right Ventricle; D is the Left Auricle, which performs the ſame Function to the Left Ventricle; K K are the *Arteriæ Coronariæ*, and the *Venæ Coronariæ*, which feed the Heart, and provide it with Blood.

Sect. III. *The Eminence or Protuberance in the* Vena Cava.

But here the Stream of Blood deſcending from the *Vena Cava* at E, meeting with another Stream aſcending at F, ſeems to threaten the apparent Danger of theſe two Currents ruſhing againſt each other, either within the Ventricle or Auricle of the Heart; for that Blood which comes down from E, aſſiſted with its own Weight, and having therefore a greater Strength, might hinder the other, which coming up from F, runs againſt it, from purſuing its Courſe; and ſo the Circulation of the Blood, and therewith the Life itſelf, might ſoon come to an End.

Now to prevent theſe Inconveniences, that would otherwiſe be ſo dangerous, we find that between theſe two Veins E and F, (both which are repreſented at A A, *Tab.* II. *Fig.* 4. where they are laid open) there is a Protuberance B, compoſed of the Fat that lies under, againſt which the Blood deſcending from E, runs or ſtrikes, and by that means the Courſe of it is turned to the Right Auricle of the Heart; whilſt the Blood aſcending from F, is by the ſaid Protuberance B covered and ſecured againſt the oppoſite Courſe of the deſcending Blood, and ſo is obliged to turn its Courſe aſide to the Ventricle of the Heart.

We muſt likewiſe here obſerve, that this Protuberance B is much greater in a Man (becauſe in conſequence of his erect Poſture, the upper Blood at E deſcends exactly perpendicular) than it is in Dogs, Horſes, Cattle, and the like Creatures, in which the Courſe of the Blood at E F is only horizontal, and therefore does not move with ſo great Force.

Once again: How very *wonderfully* are we made! And can any body ſee, without terrible Emotions, that as our precious Life, in the *Ductus Chyliferus*, does entirely depend upon ſuch ſlender and minute Valves, ſo it does here upon ſuch a ſmall Protuberance as is deſcribed at B? If here were no expreſs Deſign of the adoreable Creator, why do we find it juſt in this Place? why is it bigger in a Man, where there is a Neceſſity in Nature for its being ſo, to balance the Force of the deſcending Blood; and leſs in ſuch Creatures, where ſuch Balance is not wanting to perform the ſame Service?

Sect. IV. *The Auricles of the Heart.*

Furthermore, the Course of the Blood, which continually passes thro' these Veins A A, seems to require, besides the Heart, another Resting-place to be contained in, during the Time in which the Heart contracts itself in order to discharge the Blood, and while the Valves of the Orifice of the Right Ventricle are shut; to the end that it might be there collected in the mean time, and as soon as the little Valves are again open, be swiftly emptied into the Heart; for which Purpose the Auricle C, (*Tab.* II. *Fig.* 3.) serves on the right Side of the Heart, as D does on the left, which whilst the Passage thro' the Valves is stopt, are full of the Blood that runs into them, and are provided, after a wonderful manner, with Muscles and other Instruments, by which means each of them can swiftly contract it self as there is Occasion, and lose no time in the sudden Discharge of the Blood into the Right and Left Ventricles of the Heart.

Sect. V. *The Operation of the Heart.*

The Blood being now come thither at the time when the Heart does as it were loosen and open itself (I do not here dispute whether there be a Faculty in the Heart required for that Purpose) it contracts itself suddenly, and with great Force; insomuch, that the Sides of the Right Ventricle approaching each other by such a Contraction, and the upper and lower Ends thereof being likewise drawn together, the whole Cavity is in a manner closed, and the Blood thereupon driven out with great Swiftness into the Lungs thro' the Pulmonic Artery, or *Vena Arteriosa* G, (*Tab.* II. *Fig.* 3.) and goes onward thro' the Pulmonic Vein, or *Arteria Venosa* H, to the Left Ventricle of the Heart, after it has been distributed thro' the Lungs.

One may have a gross Conception of this Working of the Heart, by comparing it to a Bellows full of Water, in which there are two round Holes at Top; the one of which, upon the Closing or Contraction of the Bellows, is stopt with a Valve, whilst the other remains open; now, in case you should with a sudden and violent Motion press the Sides thereof together, so that in a Moment, or in the time of one Pulse, the whole Cavity thereof were taken away, it can scarce be imagined with how great Swiftness the Water in the Bellows would spring out of the Orifice which remains open: And this is a rough Idea of the Manner in which the Blood is suddenly extruded from the Right Ventricle of the Heart into the Lungs.

Sect. VI. *The Course of the Muscular Fibres.*

Now, in order to perform this so sudden and violent Contraction, or Systole of the Heart, the Muscular Fibres of which it is composed are so wonderfully and so peculiarly adapted to this very End, that he who is not wilfully Blind, and under a deplorable Hardness, must herein necessarily discover the Hand of a Wise and Designing Creator. That this is not said without good Grounds, will appear plainly enough to such as please carefully to consider the Course of these Fibres.

For you may see first, the Fibres A and B, (*Tab.* II. *Fig.* 5.) running obliquely from Top to Bottom, and others described by C and D, crossing the former; both these oblique Fibres being contracted in their Operation, the Cavities of the Heart must become narrower, and both its Ends in some sort likewise drawn together. Besides these, there are other Fibres that lie above them, and run streight upwards, (*Tab.* II. *Fig.* 6.) which only belong to the Right Ventricle, and by contracting themselves, do shorten the same. But the Course of the Fibres, that perform the same Work in the Left Ventricle, is wonderfully surprising; for those A B, (*Tab* II. *Fig.* 7.) running on all sides from Top to Bottom, encompass the Heart at the Point C, and being contracted, draw the same upwards towards A: These Fibres are represented upon the said Point or sharp End, as you may see *Tab.* II. *Fig.* 8.

Now, in order to assist the lateral Contraction of the oblique Fibres, we may observe a row of other Fibres, A C B, (*Tab.* II. *Fig.* 9.) running under the oblique ones, which perform their Function, by encompassing the Heart cross-wise, and contracting the same; so that here is in a manner the like Disproportion of Muscles as has been shewn above in describing those of the Belly: This whole Matter is largely treated of in that little, but accurate, Discourse of the Learned Dr. *Lower.*

Let any Body now that understands these Things, seriously consider with himself, whether it be possible, that such a variety of Rows of Fibres, endowed with such a great Strength together (as has been demonstrated by *Borelli*) and all serving to that very Purpose for which the Heart seems alone to have been form'd, that is to say, by its Contraction, to protrude the Blood it has received, into the Arteries joyn'd to it; I say, whether all those Fibres can have acquired this wonderful Disposition, without Wisdom and without Design?

Now, since there are not hitherto any other Muscles discover'd in the whole Heart, save those that contract it, and render its Cavities narrower; is this likewise by Chance, that the Fibres thereof when once contracted, are not suffer'd to continue in the same Condition, but presently dilating themselves, do open the Cavities, that they may again receive the following Blood out of the Veins, and by the repeated Contraction of the Heart, distribute it to the Lungs and other Parts continually, and as long our Lives do last?

Sect. VII. *The Action of the Valves of the Veins.*

There still remains another Difficulty in the Use of the Heart, *viz.* that (since each Ventricle has two Orifices, one by which the Blood enters, and the other, by which it goes out again) it seems to be a Consequence thereof, that the Heart being so suddenly and strongly Contracted, the Blood should flow at once out of both of 'em, and so be forced backwards by the same Passage by which it enter'd into this Ventricle.

To prevent the same, the wise Power of the wonderful Creator does again appear, who for this Purpose has been pleased to place there another sort of Valves (which, by reason of their Triangular Figure, the Anatomists call *Mytrales*, because they represent a Bishop's Mitre) that part of both the Veins, thro'

thro' which the Blood is discharged into the Heart; and these, when the Heart contracts it self, and the Blood is thereby driven towards the Orifice, in the Circumference whereof they are placed, are thereby shut very closely: These Valves (which we can hardly look upon without Amazement, if we consider the Providential Views of the Creator) are fasten'd to the sides of the Ventricles with a great many tendinous Fibres, that are very strong, in order to secure the Valves when they are shut, like so many Bars and Chains upon Doors, to the end that the Force wherewith the Blood that was squeezed out of the Ventricles acting against them, may not break them open, or bend them in such manner on the other side, as to make a Passage thro' them for the Blood; especially, considering that they are composed only of thin and flexible Membranes, and not of Bones or other solid Matter.

These Tendinous Fibres, have moreover the following remarkable Uses: *First*, That as the Heart after its Contraction, does again dilate it self and become longer, and consequently the Sides of it, which were raised upwards, do sink down again; I say, the said Fibres being fasten'd to the Sides, draw the Valves open (as is done in the Gates of some Sluices with Ropes) in order to make a free Passage for the returning Blood. *Secondly*, That these Fibres are fasten'd in such a manner to some little Protuberances, or Pins of the Sides of the Heart, and even to the opposite Side also, that they can hinder those Valves from falling down flat, or from touching the Sides of the Heart, to the end that the Blood, in the Contraction of the Ventricle, may press against these Valves continually from below, and so raise them upwards, in order to close their Orifices.

Sect. VIII. *Convictions from the foregoing Observations.*

I Have given an Account of the chiefest of these Matters by Words only, without adding any Figures to them; having found in the most accurate Books of Anatomy, that the best and most exact Figures taken from the Original, are not capable of giving much Light, by reason of the vast Number of Particulars that are observable therein, to such as have not viewed the same in the Heart of any Creature; for they would require more Study and Application to be understood, than even the Structure of the Heart itself. They that would make a Tryal thereof, may consult the *Fourth Figure* in the *14th Table* of Monsieur *Verheyen*, and the *First Figure* in the *5th Table* of Dr. *Lower*.

Farther, if there were any known Machine to be met with, the Operations whereof had any Analogy or Similitude with those of the Heart, the Description of it might, perhaps, render this Account a little clearer; but neither Pumps, nor any kinds of Spouts, no, not even the Modern Engines for quenching Fires (tho' in the opening or shutting of their Valves, they may seem in some manner to imitate the Heart) nor any thing else that Art has yet been able to produce, can any-wise come near them, to represent the great Wisdom wherewith this wonderful Machine of the Heart is formed. Can any Man then imagine, that this great Work has been made by Chance,

when no Body dares affirm the ſame, even of all thoſe other imperfect Machines that have been mention'd above?

Having oftentimes meditated upon theſe Things, I have thought with my ſelf, *how fearfully and wonderfully we were made*, as upon two other occaſions has been mention'd before; for in caſe one of theſe Valves ſhould be out of order, and unfit to perform its Function; yea, if one of theſe little Fibres, which are faſten'd to the Valve and draw it up, ſhould break, or be either too ſhort or too long, theſe little Sluice-Gates could not be ſhut, as not being able to approach each other, if the Fibres were too ſhort; or, if too long, not able to remain ſo, but forced to give way to the Preſſure of the Blood; inſomuch, that not only upon each of theſe little Valves, but, which is yet more amazing, upon the various Length of theſe fine Fibres, the Life of ſo Artful a Machine as every Man is, yea, even the Lives of Kings and Princes themſelves, and of all Creatures whatſoever, do entirely depend.

Sect. IX. *The Valves of the Arteries.*

This being ſaid of the Orifices, thro' which the Blood paſſes into both the Ventricles of the Heart, there was yet danger, that when the Blood was protruded from the Right Ventricle into the Artery of the Lungs, and out of the Left into the Great Artery, the Heart opening itſelf again, and the Expulſive Force ceaſing with the *Syſtole*, the Blood by its Weight might go back into the Ventricle of the Heart from whence it came, and ſo, by obſtructing the Circulation, cauſe immediate Death.

But here the Care of a moſt merciful Creator has interpoſed, by placing other Valves again at the beginning of both theſe Arteries, which perform juſt the contrary Function to the foregoing; ſo, that as the former were ſhut by the Blood that endeavour'd to aſcend from the Heart, theſe are ſhut by that which deſcended to the Heart: And, whereas the firſt were open'd by the Blood that ran to them, the ſame is effected in theſe, by the Blood that iſſues out.

That this may be more clearly conceived, let (*Tab.* II. *Fig.* 10.) *a a* repreſent the open'd Part of the Left Ventricle of the Heart; *c* the Great Artery diſſected lengthwiſe; *b b b*, the three Semi-lunar Valves, which are ſhut by the returning Blood: Here they appear lying flat and extended, whereas, otherwiſe they fill the round Orifices of the Artery; *f f* are the three Triangular, or Mitral Valves, turned aſide, that you may ſee the other *b b b* the better; and at thoſe *f f*, one may obſerve the Fibres *f g* ſtill hanging, the Ends of which *g g*, are ſhewn cut off from the ſides of the Heart, to which they are otherwiſe faſten'd, when in their natural State.

How theſe little Valves *b b b*, are diſpoſed by the Blood that is driven back, and how they ſhut the Artery, may be obſerv'd *c c c* (*Tab.* II. *Fig.* 2.) The Appearance is likewiſe the ſame, if you blow into the Artery A; B B are the Coronal Arteries (*Arteriæ Coronariæ*) which feed the Heart, and carry their Blood thither; the Openings of which into the *Aorta*, or Great Artery, are repreſented in (*Tab.* II. *Fig.* 10.) *d d*, exactly above theſe Valves.

Sect.

Sect. X. *The Lateral Muscles of the Heart.*

All the admirable Curiosities observable in the Heart, would be too many to be here nicely examined into. The Lateral Muscles in the Right Ventricle of the Heart (to pass by a great many other wonderful Contrivances in that Organ) seem here to require more particularly an immediate Attention; these Muscles, holding the Sides of the Heart together, hinder it from being too much extended by the Blood that falls into it at each Diastole, and so serve for a Measure of the Quantity that is to be poured into it at each time; they do likewise contribute to the bringing the Sides nearer together in the *Systole* or Contraction of the Heart. Thus, we likewise perceive, that the left Ventricle is encompassed with much stronger Muscles and Walls than the Right, which appears when you cut the Heart a-cross; because, that this last is only to convey the Blood thro' the Lungs, which bears no Comparison with the Distance (*viz.* the extreme Parts of the Body) which it arrives at by the force of the Left Ventricle of the Heart. Whether this Force be wholly determin'd by the Contracting Muscles of the Left Ventricle; or whether the Arteries afford any co-operating Power towards this Motion of the Blood, is yet a Matter in dispute: But this is certain, that whatever Force conveys the Blood to the Extremities of the Body, contributes towards furnishing it there with the Means of returning to the Heart by the Veins. If People cannot here discover the Views and Designs of their Great Creator, their Blindness is much to be lamented: Yea, ought not every one to stand amazed, that sees so much Swiftness communicated to the Blood, by such a soft fleshy Instrument, in order to perform so great a Circulation in so short a time?

Sect. XI. *The Force and Power of the Heart, represented by Comparisons.*

He that doubts whether the Systole of the Heart is a Force sufficient of it self to bring about such a Circulation, may, without Mathematicks, observe how great a Force and Swiftness is performed by the Compression of two Bodies, by taking a Cherry-Stone, and suddenly squeezing it between his Fore-finger and Thumb, which will cause it to fly out more swiftly than a Person never making that Observation cou'd easily imagine. By taking a handful of wet Clay, and compressing it suddenly, as the Heart does the Blood, another notable Instance offers it self; for, by observing how nimbly the Clay bursts out, wherever there is a Passage for it between the Fingers; and, considering at the same time, that this Clay has five Places to come out at (three between the Fingers, one at the Top, and another at the Bottom of the Hand) this Conclusion (which illustrates the Motion of the Blood from the Heart) naturally results; *viz.* that if the Clay issued out only through one Passage (instead of five) the Velocity wou'd be five times greater. After the same manner the Spittle, which is produced in the Mouth by Smoaking Tobacco, is discharg'd with great Swiftness; this is perform'd by collecting the Moisture into a Cavity between the Tongue and Lips, which Cavity they afterwards destroy, by thrusting the Tongue against the Lips, and so force the

the Spittle out. One might instance in other Cases, but this is sufficient to represent, in some sort, the Purpose in hand.

Sect. XII. *The* Pericardium, *or little Bag of the Heart.*

Add to all this, that the Heart is preserved in a Membranous Bag, called the *Pericardium*; which, by furnishing a Liquor from its little Glands (concerning this, see *Bergeus*, *Malpighius*, &c.) does continually keep the Heart smooth, and fit to perform its constant powerful Motions, hindring its External Membrane from being wrinkled by too much Dryness; and it lubricates and moistens the adjacent Muscular Fibres, by which means this wonderful Instrument is enabled to perform its necessary Functions, which otherwise would be obstructed.

Sect. XIII. *Convictions from the foregoing Observations.*

To say no more; after the Contemplation of this Heart in all its abovementioned Circumstances, can an unhappy Philosopher, even the most ill-natured and obdurate Atheist, be easy in maintaining, that all this is performed without Wisdom, without Design, and only by ignorant Causes? Since he cannot but know, that he would be taken by all Men, and, without doubt, by himself too, for a very foolish Person, in case he durst affirm, that a Fire-Engine only (which by no means is to be compared with the wise Contrivance and Structure of the Heart) was produced by Chance, and without the Concurrence of a skilful Workman. Let him also add, that this Machine is made and put into Motion by another; so that the whole is performed in his own Body, not only without his Will, but even without his Knowledge and Perception; and will he not yet see that his dear and precious Life is supported by another, who has shewn so great Wisdom therein? How can any one conceive, that this Motion of the Heart, according to the Calculation of the famous Mathematician *Borelli*, must be performed by the exerting of more Force at every Pulse, than is required to surmount the Resistance of some thousand Pounds Weight? That such a Motion is performed above two thousand times in an Hour, without ever ceasing, whether we wake or sleep, for the Space of fifty, sixty, or seventy Years perhaps? And particularly, since our other Muscles, after much less Pains, and sometimes but in one Day, become so tired and impotent, which never happens to the Muscles of this little Heart in so many Years. And cannot then so great a Matter, brought about by such wonderful Instruments, and after so amazing a Manner, convince every Man that is reasonable, and make him conclude with Certainty, that a Power far exceeding Humane Knowledge is here exerted.

Yea, none can deny, that according to what we have just now shewn, that as often as he lays his Hand upon his Breast, and feels his Heart beat, that this Motion is performed without his own Concurrence, and consequently by that of another.

CONTEMPLATION VII.

Of Respiration.

Sect. I. *The Air is necessary to the Blood.*

THOSE who have read the preceding Discourses, are already informed, that the Blood discharges it self from the Veins E and F, *Tab.* II. *Fig.* 3. into the right Ventricle of the Heart; from thence it is introduced into the Lungs (by the Systole of the right Ventricle) thro' the *Vena Arteriosa*, or Pulmonic Artery G; and from the Lungs it is again discharged into the left Ventricle of the Heart, by the *Arteria Venosa*, or Pulmonic Vein H.

Now whether the Blood passes from one of these Tubes into the other immediately, or whether it passes thro' that Substance of the Lungs which is of the Nature of Bellows, we will not here enquire; this is certain, that the Air sucked into the Lungs where this Blood is, does, as long as Life last, come in and go out again; and whatever the Use of it be, it is so great, that no Man can want it a short space of Time, without presently dying; and it is no less probable, that the Instruments by which the Air is conveyed into the Lungs, are made with great Skill and Contrivance.

Sect. II. *The Blood Vessels and* Aspera Arteria *in the Lungs.*

He that doubts of this, let him take the Lungs and Wind-Pipe of a Lamb, or any other Animal, in which may be observed, 1. That the upper Orifice of the said Wind-Pipe can be covered with a small Cartilage, called the *Epiglottis*, whilst the Food is descending thro' the Gullet, that lies behind it, into the Stomach. 2. That whereas the Branches of the Wind-Pipe, which spread themselves into the Lungs, are cartilaginous, and of a round or cylindric Figure, that they may always remain open; yet the Wind-Pipe itself, where it lies upon the Gullet, that it may not hinder the Passage of the Air in the fore Part of it, does by its Cartilages compose part of a circular Figure only, and behind has only a Membranous Covering, because the Cartilages perceivable in the fore Part of the Wind-pipe would press too hard upon the Gullet, thereby incommoding the Passage of the Food. 3. The wonderful Structure of the Air-Tubes, or Branches of the Wind-Pipe, (*Tab.* II. *Fig.* 12. A E) which passing throughout the Lungs, lie between the two Blood-Vessels B E and C E; of which B E serves for a Passage to the Blood that enters into the Lungs, and C E to that which coming out of the same enters into the left Cavity of the Heart. The same is observed to happen con-

constantly in these Lateral Branches; the Blood-Vessels being cut off here, they are represented finer, and the Ramifications of Air-Vessels interwoven with them, are more commodiously described.

Sect. III. *The Glands in the Wind-Pipe.*

But if it was necessary to use great Care in the Formation of any Part of the Body, it seems to be mostly so here; to the end that this Tube (which as long as we live, or whether we wake or sleep, admits of a constant Influx and Reflux of Air) should not by this Air grow dry. Is there then no Design to be traced and observed here? Since the Omniscient Creator has cloathed the same on the inside not only with a Glandulous Membrane, from which a Humour is always filtrating; and in order to moisten the Throat itself, has been pleased to place two Glands called the *Thyroideæ*, of a considerable Bigness, for that Use, besides those other Glands which we commonly name the *Almonds*; but further to manifest his intended Purpose more clearly, has planted in all those Places where the Air-Vessel is divided into Branches, very visible Glands for the Moisture thereof; (whether they have any other Uses besides, we are not now enquiring:) And forasmuch as the *Epiglottis*, by reason of the continual passing and repassing of the Air that strikes upon it, seems almost impossible to be kept moistened, and if it were dry, could not so well discharge its important Function; can any one see, without Astonishment, how the great and wise Contriver thereof, has furnished this Cartilage with so many little Glands above and below, in order to moisten it beyond all others!

Sect. IV. *A Hundred Muscles requisite towards Respiration.*

Not to mention here the Divisions of the Wind-Pipe into so many Cartilaginous Rings, nor the Membranes and Fibres by which they are fastened to each other, nor the wonderful Structure of the *Larynx*, consisting of so many Cartilages, and moved by fourteen Muscles, to the end that by all this *Apparatus*, the Wind-Pipe and its Orifice being several ways lengthened and shortened, dilated and contracted, the Voice might be thereby formed, and yield a more shrill or deep Sound; which Things being now become the Object of the Inquiry of several great Naturalists, we shall here confine ourselves only to Respiration, and content ourselves with asking any one that does still question the Wisdom of his Creator, whether he can believe that the Instruments, which besides the Lungs are necessary thereto, could be ranged and placed near the others without any Understanding or Design? Especially if it should be proved to him, that altho' the Midriff alone is sufficient for Respiration, yet to the end that so necessary a Work as this is might not easily be obstructed, about a hundred different Muscles are likewise applied to the same Purpose; and, as easy as the Action of Breathing may appear to be, that in a strong Respiration (when every one of this great Number of Muscles, that are capable of being used therein are employed for the Purpose) before the Breath be drawn in, and driven out again, this great Number of Muscles must have all been employed for that Purpose.

This is ſufficiently known to the Anatomiſts; and, to give you a ſmall Sketch of it here, we ſhall inform you, that in drawing in the Breath, in order to raiſe up the Ribs and the Breaſt-Bone, and thereby to dilate the Cavity of the *Thorax*, or Breaſt, there are put in Motion on the one Side, one *Muſculus Subclavius*, eleven *Intercoſtales Externi*, eleven *Levatores Coſtarum*, beſides the *Serratus Anticus Minor*, the *Serratus Anticus Major*, the *Serratus Poſticus Superior*, and the *Cervicalis deſcendens Diemerbroekii*, beſides three others which are therefore called *Common*, becauſe they likewiſe perform other Motions, *viz.* the *Pectoralis*, *Scalenus*, and *Levator Scapulæ*, which together make thirty Muſcles on one Side; and there being as many more on the other, are in the whole ſixty, that are alone employed in *Inſpiration*, or drawing our Breath inwards.

Towards *Expiration* there are likewiſe employed nineteen Muſcles of a Side, eleven *Intercoſtales Interni*, the *Triangularis*, the *Sacrolumbus*, and the *Serratus Poſticus Inferior*, and with theſe alſo five *Common* ones, *viz.* the Muſcles of the Belly; theſe are altogether thirty-eight Muſcles, uſed for Expiration only, which being added to the ſixty above, make together the Number of ninety-eight: Now if you add to theſe the Midriff, being the principal Inſtrument of them all, and which, according to the Opinion of that great Anatomiſt *Verheyen*, conſiſts of two, or it may be three Muſcles more, there muſt, according to this Computation, be at leaſt a hundred Muſcles made uſe of in one ſingle Action of Breathing as ſtrongly as we can. Theſe Obſervations we find made in the *Acta Lipſienſia*, *Anno* 1707. of *J. G. Pauli*, upon *Van Horne*.

I would now ask again, whether any Body can ſuppoſe that ſuch a Diſpoſition, where there are ſo many Muſcles conſiſting of Fibres extended ſo many different Ways, is produced by Chance, or without Deſign? Or whether it does not plainly appear to him, that this great Compoſition of the Muſcles is expreſly adapted to the End of Breathing?

Sect. V. *Without Air this whole Structure is uſeleſs.*

But if what has been here mentioned concerning the Diſpoſition of theſe Muſcles, ſhall appear wonderful in every Man's Eyes, will he not yet ſtand more amazed at the Wiſdom of the great Director of all Things, when he finds that all theſe Inſtruments, tho' never ſo artfully adapted to Reſpiration, would be yet in vain, and of no manner of uſe, if Mankind, and all other Creatures breathing, were not ſurrounded with ſuch a Matter as the Air is, which has in it, among other Properties, an Expanſive Power (*Vis Elaſtica*) beſides a Weight, which cauſes it to operate and dilate itſelf; from whence it comes to paſs, that as ſoon as the Breaſt is enlarged by the Operation of the above-mentioned Muſcles, this Air immediately ruſhes into the Wind-pipe and Lungs; of which Property (taking it at preſent for granted) we ſhall treat more largely hereafter, when we enter upon the *Contemplation* of the *Air* itſelf; and we ſhall prove experimentally, that in an Air which is but partially diveſted of this *Elaſtic Force*, almoſt all Creatures will immediately periſh.

Fig. 1

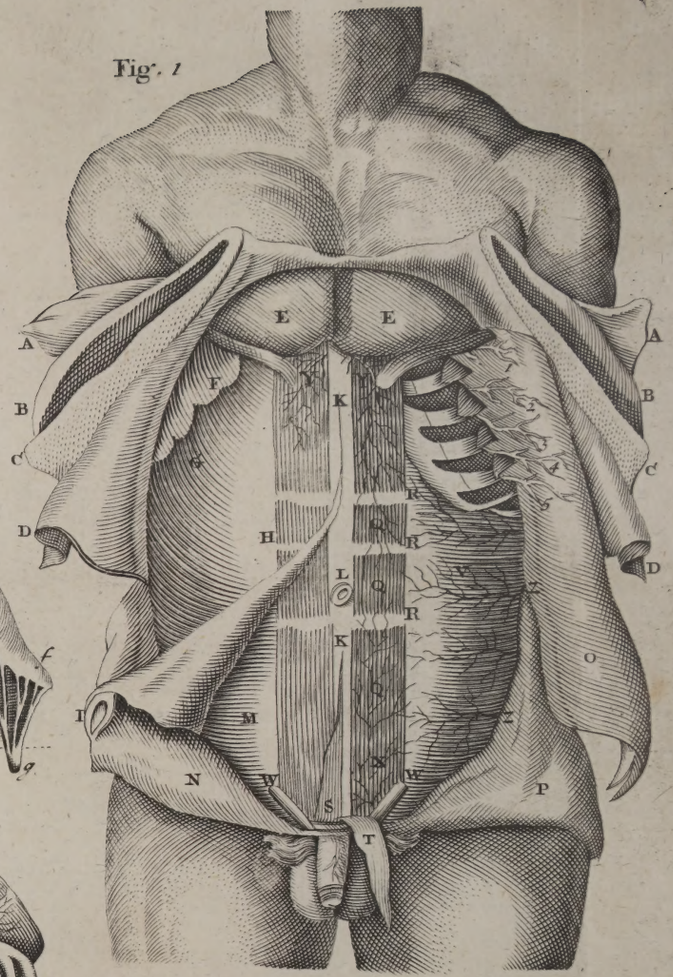


Fig. 3

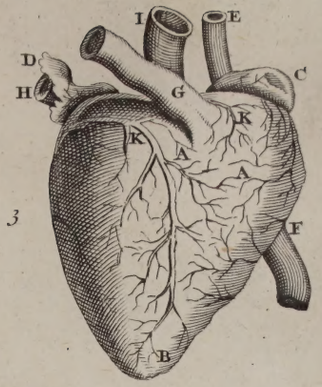


Fig. 2

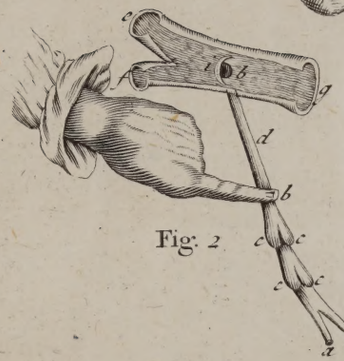


Fig. 10

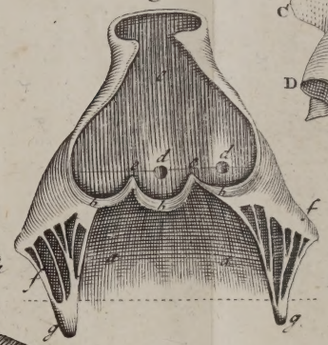


Fig. 6

Fig. 11

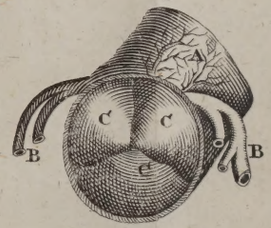


Fig. 12

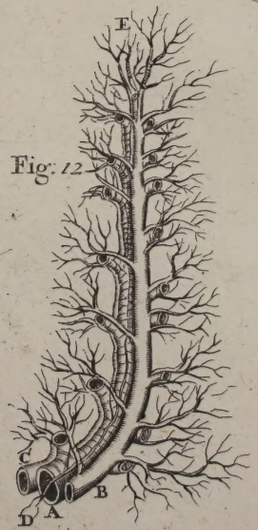


Fig. 4

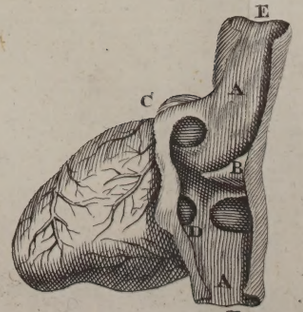


Fig. 8

Fig. 7

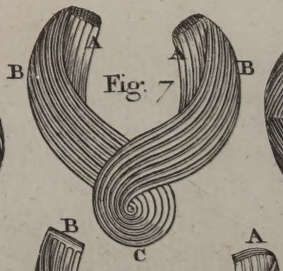


Fig. 9

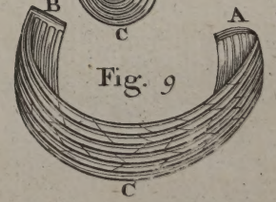
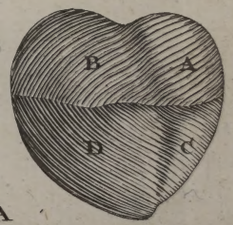


Fig. 5.



Sect. VI. *The Properties of Expanded Air.*

However, that we may here give you some Idea of Respiration, it will be necessary to represent previously, 1. That when the Place in which any Air is shut up, is made larger, the said Air filling a greater Space, is so much the more weakened in its expansive Force. 2. If the Air thus weakened has any Communication with other Air that is stronger, and both of 'em can act upon each other, the stronger Air will immediately rush into the enlarged Place, in which the weaker was contained.

Sect. VII. *The Comparison of Respiration with a Pair of Bellows.*

To prove this by a Comparison, one need only represent to one's self a Pair of Bellows (*Tab.* III. *Fig.* 1. A E F) in which we know that nothing more is requisite in order to draw the Air into the Mouth A, or Tube A B, than to separate the Sides E D and F G from each other; by which Means the Space E D G F is inlarged; and so the Air that was contained therein being weaken'd, and not powerful enough to balance the external Air (with which it had a Communication by the Tube A B) the last being now become the strongest, does, by its *Elastic* Force, crowd itself into the Mouth of the Bellows.

The same thing would happen, if one supposed that a Bladder B C, were fastened to the Tube A B without the Bellows; in which Case the Space K being dilated, the Air therein would likewise be too weak to resist the Air which fills the Hollow of the Bladder B C thro' the Tube A B, by which means this Bladder will be blown up, and expanded by the stronger external Air rushing in upon it.

Now if you suppose the Tube A B to be the Wind-pipe, the Bladder B C the Lungs, and the Space thereof E D G F the Cavity of the *Thorax* or Breast, you will see the Reason why the Air rushes thro' the Wind-pipe into the Lungs, to which it is fastened like these Bellows, when by pressing down the Midriff, and by the other Muscles, the Breast is made wider and larger.

He that desires farther to see how the Lungs, whilst hanging to the Wind-pipe, may be puffed up by the Air, need only take the trouble of blowing strongly into the Wind-pipe of a Sheep or Ox newly killed; by which means he will see the Lungs, like a Pair of Bellows, expanded by the Wind that passes into them.

Sect. VIII. *An Experiment upon the Lungs in* Vacuo.

I Have represented these Appearances after such a gross Manner, to the end that those who have not the Opportunity of using the Air-Pump, may have some Conception thereof; but those that have used this extraordinary Instrument, so necessary in examining the Works of the great Creator, may form to themselves a much clearer and more distinct Notion thereof.

Let the Covering O P be laid upon the Glass or Receiver O P F, *Tab.* III. *Fig.* 2. standing upon the Air-Pump, which has a little Tube A N B passing thro' the Centre of it, and a little Cock at N, which now appears open,

but

but may be ſhut; under this Covering, at the Extremity of the little Tube A N, there is another ſcrewed on at B C, the End of which is ſtuck into the Wind-pipe of a little Piece of Lungs D, which is tied faſt to it.

Now when the *Piſton* Sucker L M of the Air-Pump is thruſt to I K, or ſo far inwards as poſſible, one ſees that the Piece of Lungs D hangs in the Space E, that does not extend it ſelf farther than from O P to I K, when the Cock G H is open, in which Space the internal Air is ſhut up; the little Cock at N being turned, the Sucker is drawn backwards from I K to L M; by which means the Space that contained the included Air is ſo much larger, as the Diſtance between I K and L M; both Spaces being filled by the Expanſion of the Air, which therefore loſes a great deal of its Elaſticity: This will appear, if you open again the little Cock N, when the external Air ruſhing into the Piece of Lungs D thro' the Tube A B, blows it up; the Reaſon of which is, that this Air having loſt nothing of its Elaſticity, preſſes more ſtrongly into the Lungs D from without, than the included Air at E, which preſſes it inwardly, is able to reſiſt, becauſe of the weakning of its Spring.

That this is true, will hence appear, foraſmuch as if you thruſt the Sucker L M forwards to I K, and reduce the included Air into a narrower Space, it will again ſtrongly expand itſelf at E, and preſſing with more Violence the Lungs D, will make them become ſmaller, by forcing the Air which was in them to go out again thro' the Tube B A; and this Effect you may produce as often as you repeat the Experiment, by drawing or thruſting the Sucker backwards or forwards. Now if you will ſuppoſe the Tube A B to be the Wind-Pipe, the Space O P K I to be the Cavity of the *Thorax*, and the Sucker L M the Midriff, there will be a mighty Analogy between this Experiment and the Buſineſs of *Reſpiration:* And the whole Difference is only, that whereas the Cavity of the *Thorax*, in which the Lungs hang, is dilated and contracted by the Muſcles and other Inſtruments, the ſame Effect is produced in the Air-Pump, only by the Sucker thereof.

Now ſuch as don't think it worth the while, or have not the Opportunity of making this Experiment with the Lungs of any little Animal, may make uſe of an empty Bladder D, tying the ſame to the End of the little Tube B C, which will give you all the Appearances very conveniently and agreeably, ſo that with but half a turn of the Handle of the Air-Pump one way or other, you may fill or empty the Bladder of Air.

Sect. IX. *An Experiment with a little Bottle of Water.*

Now if any Body has a mind to ſee with his own Eyes, after what manner and how violently the Air crowds itſelf into the Lungs as ſoon as the Cavity of the Breaſt is enlarged; inſtead of a piece of Lungs or Bladder, let him take a little Glaſs Phial, holding about an Ounce or ſuch like quantity of Water, and tye it to the Tube B C, ſo that the End of the Tube may be thruſt as far as it can into the Water, then ſhut the Cock N, and enlarge the Space as before, by drawing back the Sucker to L M; let him open the little Cock N, and he will ſee that the External Air, which by its ſtrong expanſive Faculty forced itſelf inwards, will put the Water into a very violent Motion,

tion, juſt as if any Body ſhould ſet his Mouth to the other end of the Tube A, and blow thro' the Water as hard as he can.

Sect. X. *The Experiment of a Syringe in* Vacuo.

Now, in order to convince every one experimentally, that altho' a Space be inlarged, as happens in the *Thorax*, when we draw in our Breath, or even, tho' a ſpace be made where there was none before, as in a Syringe, by drawing up the Sucker; there are nevertheleſs Caſes, in which, if the Matter that otherwiſe riſes up in the Syringe has no Expanſive or Elaſtical Parts in it, or is not moved or preſſed after ſome other manner, it will by no means run into the empty Spaces, in order to fill the ſame. Let any one but caſt his Eye upon this little Machine, F H I, (*Tab.* III. *Fig.* 3.) which is commonly to be found in the Shops of thoſe that make Air-Pumps, and he will ſee, that if an empty Space be made in the Syringe A B, by drawing up the Sucker F A, (after having firſt diſcharged the Air at G, out of the Glaſs-Bell H B I, thro' the Air-Pump) the Water in the little Glaſs D E, in which the Tube of the Syringe ſtands B C, and which is open at C, will by no means riſe up into the Tube, nor fill the empty Space in the Syringe, as uſually; becauſe the Water D E, has no ſenſible Elaſticity or Spring in itſelf, nor is acted upon by any other Elaſtick Body, which in this Circumſtance would be requiſite: from whence one may conclude, and not obſcurely neither, what we have already ſaid concerning Reſpiration, *viz.* That altho' there be Space enough prepared in the Breaſt, in order for Breathing, yet, in many Caſes, no Air (if, like the Water, it ſhould happen not to be elaſtick, nor heavy enough) would come in: All which is yet hereby more evident, that ſo ſoon as one lets in the Air again into the Glaſs-Bell, H I B, the ſame gravitating upon the Water D E, by its elaſtick Force, immediately cauſes it to riſe up into the Space that was made for it at A B, thro' the Tube B C, in which, as there is now no Air remaining in it, there is no Reſiſtance.

Sect. XI. *Convictions from the foregoing Obſervations.*

Now let the proud and haughty Creature called *Man*, think once ſeriouſly with himſelf, and ſee whether he can find any Subterfuge, whereby he may avoid owning, that he is obliged, like the meaneſt Beggar, every time he fetches his Breath to repreſent his Poverty to his Maker, and his Inability of preſerving his own Life but one minute; and to beg him, that he would vouchſafe to fill his empty and gaping Lungs and Breaſt with freſh, good and wholeſome Air, and ſo continue his Life from one inſtant to another: And can any Body contemplate with Attention, this Nothingneſs of himſelf, and abſolute Dependance at every Breathing, upon his great Preſerver, and the ſo many Thouſand, yea Millions of Times, in which this gracious Benefactor has moſt freely granted him Breath, and conſequently his precious Life, during ſo many Years; and yet remain, not only ungrateful to him, but even deny all his adoreable Attributes and Perfections, even thoſe that he has found ſo beneficial to himſelf; and, if it were poſſible, wiſh to annihilate the

the ſame. What ſhall be ſaid of ſuch unreaſonable and impious Opinions, but that they ought to be deteſted by all Generous and Grateful Souls.

Sect. XII. *The Uſe of Reſpiration.*

We ſhall not here enquire more largely into the Advantage which this Reſpiration (the Manner of which we have hitherto treated of) gives to Mankind: Since the moſt Learned Naturaliſts are not entirely agreed, whether it ſerves to cool the Blood, or whether it be to procure a more convenient Paſſage for the Air alone thro' the little Tubes of the Lungs, and thereby to produce a better Mixture of Blood, or, laſtly, to communicate a Nitrous Spirit to the ſame in the Lungs; which is believed by many, becauſe, if the Blood running from a Vein, be mixed with Water impregnated with Salt-petre, it changes its dark Colour into a ſhining Red, and the *Serum* or Whey thereof, becomes as clear as Water, tho' containing, nevertheſs, a ſufficient quantity of Material Food, as may be obſerved by putting ſome Drops of the acid Spirit of *Nitre*, or *Aqua-fortis* therein, which will ſeparate a White Curd from the ſaid Whey. Now the Arterial Blood has likewiſe the ſame Property, being dark before it comes into the Lungs; but after having paſſed thro' the ſame, and therein undergone the Action of the Air (be it what it will) diſcovers a bright red Colour, when diſcharged into the Left Ventricle of the Heart, and when it proceeds further into the Arteries: And that which is obſerved by ſome with greater probability, is, that the Air being *Nitrous*, will change the Blood, that has been drawn out of a Vein, whilſt it ſtands expoſed in a Baſon, from a dark, to a bright red Colour, giving it a Tincture perfectly like that which it acquires by the mixture of diſſolv'd *Salt-petre*. We ſhall paſs by all theſe things, by reaſon of the Diſputes and Controverſies of Learned Men, leaving them to be diſcover'd by the following Ages, and confine our ſelves only to the Experimental Enquiry, which of the aforeſaid Benefits and Advantages, or what other are the true ones that may be affirmed to be communicated by the Air to the Blood.

This is however unqueſtionably true, that the drawing in of the Air is of ſo great a Convenience, that no Body could want it long without dying; and that our Heart, and the whole Structure of the Veins, are formed after ſuch a manner by the All-wiſe Creator, that all the Blood of the Body is made to paſs ſeveral times in an Hour thro' the Lungs, and there ſubjected to the Operation of the Air.

Sect. XIII. *The Diſpoſition of the Air in the Time of Peſtilence.*

Now of how great Importance, beſides the Elaſtical Force and Gravity of the Air, the good Diſpoſition and Conſtitution thereof is towards the Preſervation of the Lives of Men and Beaſts, is very plain at thoſe Seaſons in which the Air being corrupted, Peſtilential Diſtempers are occaſion'd, and Kings and their Subjects, and Small and Great, are ſnatched away by Thouſands: And theſe kinds of Diſeaſes muſt not be aſcrib'd to any other Cauſe, ſince, being common to all Sorts of Men, they muſt likewiſe proceed from one common Source or Spring; and that can be nothing elſe but the

Air,

Air, which is common to all Mankind. The famous Professor *Schacht* has given us an Account of a dreadful Example of this Pestilential Infection of the Air, in the last Plague at *Leyden, viz.* by exposing a Bucket of Water a whole Night to the Air, even within Doors, upon which in the Morning there stood a kind of a Cream or Scum of divers Colours, that had been communicated to it by the Air; this being gently skimmed off with a Spoon and given a Dog to drink, the Poison was so strong, that he died of it in a few Hours: And how pernicious also in general, the Corruption of the Air is, will abundantly appear from the melancholy Experiments, whereby it has been often seen, that People have been miserably suffocated, and perished in an Air to which they were accustomed all their Lives, as soon as that same Air becomes infected, and poison'd with the Smoak of glowing Charcoal.

Sect. XIV. *The Air leaves something in the Blood.*

Now the Opinion, that the Air being drawn into the Lungs, leaves something there (whatever it may be) and does not come out again of the same Temper, seems to be somewhat probable from certain Experiments, which I have found among my Notes in the Year 1695; by which it should appear credible, that the Air leaves behind it in the Lungs the same Particles which serve to maintain Flame. Concerning this, the Reader may have recourse to the *Ninth Section* of the *Twenty-first Contemplation* upon *Fire*, where the Experiment is shewn in all its Circumstances. Besides which, there is to be found in the *Memoirs of the French Academy of Sciences*, Anno 1707. p. 213. a Remark of Monsieur *Homberg*, where he says, that if any Body has been in a place where there was a strong Scent of Oyl of Turpentine, he will discover afterwards that his Urine has the same smell of Violets, as if he had swallowed Turpentine itself. Now since these fine Particles of the Oil of Turpentine do not seem to have enter'd his Body, otherwise than by Respiration, and it being very probable from the smell of the Urine, that they must have been first mingled with Blood, this Gentleman concludes, that the Air leaves some Particles behind it in the Blood; but we shall not here expatiate upon those things which some People hold uncertain.

Sect. XV. *Convictions from the foregoing Observations.*

Now can any Body, that has well weighed and understood all these things, avoid seeing that his Precious Life is in the Hands of another, and how greatly we are oblig'd to shew our Gratitude for his Goodness, in continuing the same: *His*, I say, who preserves this great Sea of Air, in which Men live like Fishes, in such a Disposition as to make it fit to perform this great Office to the whole Race of Mankind, and so many other Creatures, in preserving their Lives and enabling them to breathe? Or, can the same likewise be rectified by any Humane Means, after it is corrupted and become fatal both to Rich and Poor? Now if all this be perform'd by Chance, and without the Providence of a Gracious and Powerful Ruler, how comes it to pass, that in so many Thousand Years, among such great Revolutions that it undergoes, by Storms, Thunder and Lightning, from so many poiso-

nous Vapours exhaling from Subterraneous Caverns, and from rotten and putrified Bodies, none of 'em all have hitherto been able to deprive it of that Constitution by which it preserves the Lives of all Creatures; since if every thing be Accidental, and not under the Direction of a wise Being, the one might as easily come to pass as the other? But of these and other Properties of the Air, an express mention shall be made in its Place.

In the mean time, let every Body, that has the Knowledge of his Maker and Preserver at Heart, seriously recollect all that has been said about Respiration, and, in a silent Retreat, examine himself, whether he can maintain with Reason, that this Air is not created for this very Purpose among others, in order to preserve the Life of every Creature breathing; since this alone, and nothing else in the World, has the Qualities that are requisite thereto? And let him say, if he dares, that all that most amazing Structure of the Muscles of the Breast is formed by meer Chance only, without any Prospect of that great End of *Inspiring* and *Expiring* of the Air, since there is here likewise such a great number of Muscles disposed after so wonderful an Order, to produce that very Effect only, or hardly any other: Can he imagine, that the Lungs were made without Understanding, and placed in the Breast after the Manner we have already shewn? Whereas, if they had been disposed any otherwise, all the Properties of the Air, all the Dispositions of the hundred Muscles, which now serve this Work, would be entirely in vain, and the whole Globe of the Earth would be presently dispeopled. Can any one fancy, that so many Ribs and Cartilages, of which the Breast is composed, so many Muscles by which it is moved, together with the Midriff and Lungs, have met one another in such a little space by meer *Chance*; and that the Air also has encompassed them all without any Purpose; whereas, if but one of these Circumstances were wanting, the great Business of Respiration, and therewith the Lives of all Creatures, would immediately be ended? Can any one think, that where so many and so different Things concur to one End, the same are not made with this Design, that they shall be useful to each other? He would be asham'd to maintain, that a curious Lock and Key adapted to a strong Box, and by which alone it could be open'd, was not made by an *Ingenious Workman*, but by meer Chance, by which only they had met together. Unhappy Men! that can continue in such senseless Opinions after so long and daily Contemplations of those Works of the Creation, in which the Wisdom of the Creator is so visibly manifested!

CON-

CONTEMPLATION VIII.

Of the Structure of the Veins.

Section I. *The Transition to the Veins.*

WHAT has been said, seems to be more than sufficient not only to bring a *Sceptick* into the right Way, but even also to convince the most obstinate *Infidel*, that our Bodies must have been formed by a Wise Creator, and that the Origin thereof can be ascribed to nothing less than an *Accidental* and *Ignorant Cause*; yet, if there should still be any Body, who either thro' want of considering what has been already said, finds himself unmoved, and consequently unconvinced thereby; or, altho' he has understood it, yet should with-hold his consent to the Conclusions that flow from thence; let him go but one step farther with us, and see whether, without Contradiction of his own Conscience, he can contemplate the wonderful Structure of the Tubes thro' which the Blood circulates, and which are contriv'd for so many Purposes; and then believe, if he can, that He who formed them all, proposed no End to himself when he made them, nor knew what He himself was, nor what He had created.

Sect. II. *The Course of the Arteries.*

Now in order to the compleat Conviction of all such *Atheists* and *Scepticks*, they are intreated seriously to consider with us, whether it can be imagined, that the Vessel (*Tab.* II. *Fig.* 3.) which is called the *Aorta*, *Arteria Magna*, or *Great Artery*, has, without an over-ruling Understanding or Design, acquir'd such a Form as is shewn from *Verheyen*, in *Tab.* III. *Fig.* 4. in the particular Scituation wherein it appears in Humane Bodies.

Besides other Wonders which we don't meddle with here, we know, that there is not any one Part of the Body, as yet discover'd, in which we find that the Blood is not convey'd thither by the Branches of this great Artery, either for Nourishment or Motion, and likewise for the Separation of other Humours and farther Uses. Will any Body therefore believe, that this whole Disposition of the Arteries, has been thus contrived by Accidental or Ignorant Causes?

Now in order to impart some rough Conception or Idea hereof, which might otherwise appear a little obscure to those that are unexperienced; let us here represent to ourselves the Beginning A O of this Artery, as cut off from the Heart at O, and we shall see two little Arteries *a a*, called the

Coronary Arteries, coming out of the ſame, and turning towards the Heart; the ſame are repreſented a little bigger in *Tab.* II. *Fig.* 11. B B.

Then if you aſcend as it were ſtreight forwards, you may ſee in *Tab.* III. *Fig.* 4. the *Carotides b b*, proceeding out of this Veſſel, the Pulſe of which a Man may feel with his Finger on each Side of his Wind-pipe; theſe having, as they go on, communicated ſome Branches to the Wind-pipe and Parts adjacent, do each divide themſelves into two Branches, one of which, *e e*, goes into the Head, to the thick Membrane of the Brain, to the Mucilaginous Glands, to the Eyes, to the inmoſt Parts of the Ear, and to the Subſtance of the Brain itſelf; and t'other Branch, *d d*, proceeds to thoſe Parts that compoſe the outſide of the Head, and is the ſame which is felt in the Temples of the Head.

We may obſerve farther, that this great Artery begins to bend itſelf at A, in order to deſcend on the left Side; that on either Side there appear two great Branches, D and L, called the *Subclaviæ*; which, as at F, are again divided into two great Branches, one of which ſeems to terminate at the Elbow, and the other, E, carries the Blood to the remaining Part of the Arm, and the whole Hand, quite down to the Fingers: But before this Diviſion at F, the *Subclavia* ſends out ſeveral Branches; ſuch as the Branch *m* downwards to the Breaſt, and *n*, whoſe lateral Branches become the ſuperior *Intercoſtals*; there go farther upwards the *Cervicales c c*, otherwiſe called the *Vertebrales*, whoſe lateral Branches at *i i* diſcharge their Blood into another common Veſſel *h*, which like a Chain runs along the Back-Bone downwards. Finally, theſe *Vertebrales* go to the Brain. To ſay nothing more at preſent of all the little Branches, as *k*, which go to the Muſcles of the Neck, *o p*, to the Shoulder-Blade within and without, and all thoſe which we may obſerve to proceed from the Arteries of the Arm.

The great Artery turning itſelf now downwards at B and C, produces firſt the *Bronchialis b b*, which ſeems to feed the Lungs; this is followed by the inferior *Intercoſtals c c*, which come out here acroſs, and are cut off; and under theſe there comes forth ſometimes a Branch to the Midriff *d*, under which is the *Cæliac e*, which divides itſelf into two Branches, the Right of which goes to the Stomach, to the Cawl or *Omentum*, to the *Pancreas*, to the firſt Inteſtine next the Stomach, to the Gall-Bladder, and inveſting Membrane of the Liver; and the left, after having communicated ſome little Branches to the Stomach, Cawl and *Pancreas*, terminates chiefly in the Spleen.

Under this *Cæliac*, the uppermoſt *Meſaraic u*, comes out of the Great Artery, and runs thro' the Midriff to the thin Inteſtines, in the ſame manner as the Artery *u* does to the thick ones.

s s Are thoſe that go to the Kidneys and to the Loins; *v v* are the Spermatic Arteries.

After all theſe Branches, the whole Great Artery divides itſelf at *w* into two great Branches, called the *Rami Iliaci*, which ſending their Branches to the lowermoſt Bowels of the Belly, as the Bladder, the Matrix, and other Parts of Generation, to the *Inteſtinum Rectum*, *&c.* proceed farther on both

Sides down to the Legs, and the extreme Parts of the Toes after the ſame manner as the *Vena Subclavia* at F does to the Arms.

Sect. III. *The Courſe of the Veins.*

Now as this great Artery tranſmits its Branches to all the Parts of the Body, can any one imagine, that not one of them, how little ſoever, is to be found, to which there is not again a Vein-branch adapted? Which Branch carries that Blood back to the Heart, that was brought from thence by the Artery to all the other Parts.

Let thoſe who deſire to form any Notion hereof, caſt their Eyes upon (*Tab.* III. *Fig.* 5.) and obſerve how theſe Veins run along the Body, and after having performed their Office, carry the Blood back to the Heart: So that the ſame Blood which in *Fig.* 4. (to give one or two Inſtances thereof) was brought from the Heart thro' the *Arteria Subclavia* D, to the Extremities of the Fingers 7, 8, 9, is again received by ſmall Branches of the Vein A N, in *Fig.* 5. by which it returns thro' Q O M G, and is brought thro' a great Veſſel E, called the *Vena Subclavia* to the *Vena Cava* C, and ſo on till it diſcharges itſelf again thro' the Orifice A into the Heart.

Thus we here ſee the Jugular Veins, *Fig.* 5. *d d*, *e e*, and the *Vertebrales ff*, bringing back the ſame Blood, which in *Fig.* 4. was carried into the Head, and other Parts, thro' the Arteries *b b*, *c c*, and as before, *Fig.* 5. leading it to the Heart A, thro' the ſame *Vena Cava* C.

We muſt ſuppoſe after the ſame manner, that the Blood, which was carried down thro' the Artery T, (*Fig.* 4.) and, as in the Arm, driven to the Extremities of the Toes, is there received firſt of all in the ſmall Veins, in order to bring it back; and farther thro' the Vein I G, *Fig.* 5. along E B, (which is called, *Vena Cava Aſcendens*, becauſe the Blood paſſes thro' it upwards) diſcharges itſelf in the Heart at A.

Sect. IV. *Convictions from both the foregoing Sections.*

Now ſuppoſing the ſame Phenomena in all the Veins and Arteries, can any one imagine, that this great Artery, and the whole Diſpoſition of the Veins, are made without Knowledge and Underſtanding; or that each of them are not thus contriv'd for their particular Purpoſes, of carrying the Blood backwards and forwards? He that will venture to maintain this, how can he be convinced? And let him but ask himſelf, if ſeeing the Pipes and *Aqueducts* of a Fountain (in which there is not the thouſandth part of ſo much Skill or Art as in the Ducts of the Blood) he will dare to maintain, that he really believed that they were all diſpoſed after ſuch a manner, without any Wiſdom, or Deſign, or Contrivance of the Maſter; and that if he ſhould ſay ſo, whether he were like to find any Credit with People of good Senſe or Reaſon?

Sect. V. *A rough Repreſentation of the Circulation of the Blood.*

To the end, that an unexperienced Perſon may, in ſome meaſure, comprehend what has been ſaid above, and have ſome Idea of the Circulation of the

Blood

Blood, let him fancy, that in (*Tab.* II. *Fig.* 3.) the Tubes or Veins E and F, are the ſame that are repreſented in *Tab.* III. *Fig.* 5. by C and B; from which the Blood paſſes upwards and downwards into the Right Ventricle of the Heart, and thence thro' the Veſſel G (*Tab.* II. *Fig.* 3.) into the Lungs, and thence again thro' another Vein H, into the Left Ventricle of the Heart; which two Veſſels H and G, are ſhewn before in *Tab.* II. *Fig.* 12. by C E and B E, which encompaſs between them both, one of the Branches of the Lungs A E: Laſtly, let him ſuppoſe that the Blood is protruded from this Left Ventricle, by the Contraction or *Syſtole* of the Heart, into the great Artery I (*Tab.* II. *Fig.* 3.) which, how it diſtributes itſelf by its Branches, has been lately ſhewn in *Tab.* III. *Fig.* 4.

So that by this means the way of the ſo famous Circulation of the Blood may appear to any one that conſiders the ſame; which Blood paſſing from the Heart thro' the Arteries to all the Parts of the Body, is tranſmitted back by the Veins into the ſame; and then having paſs'd thro' the Lungs, between both the Ventricles of the Heart, reſumes the ſame Courſe again thro' the Great Artery.

He that has ever ſeen the Circulation of the Blood in the Tail of an Eel, by the help of a Microſcope, will be very well ſatisfied concerning this Motion, without our producing any farther Proofs thereof, tho' they are very numerous; and he will be no leſs convinc'd of the great Velocity, or Swiftneſs, of the Blood's Motion, if ever he ſaw it ſpringing out of a cut or wounded Artery.

Sect. VI. *How often the Blood Circulates in an Hour.*

Now that we may farther enquire how often the Blood circulates throughout the Body of a Man in the ſpace of one Day, let us agree with the Great *Harvey* in the following Poſitions.

1. That the Left Ventricle of the Heart may contain about two Ounces of Blood; tho' the accurate Dr. *Lower* has often found it larger.

2. That in each Contraction of the Heart, this Cavity is in a manner quite empty; and therefore two Ounces of Blood are at each time protruded into the Great Artery; which ſwelling up thereby, cauſes the Pulſe.

3. If we now ſuppoſe, that each Pulſe is made in a Second of an Hour, or in the *60th* part of a Minute, which every one may obſerve in himſelf, and is at preſent, for Conveniency ſake, allowed by many; this will produce 3600 Pulſes every Hour; and conſequently twice as many, that is 7200 Ounces will paſs through the Heart in the ſpace of an Hour.

4. This together will make the quantity of 600 Pounds of Blood (allowing with the Phyſicians 12 Ounces to the Pound) that will paſs thro' the Heart in an Hour.

5. Now it is the common Opinion of the Anatomiſts, that a Man has ſeldom more Blood in his Body than 24 ſuch Pounds, or leſs than 15; but ſuppoſing here, with *Lower*, that the ſame amounts to 25 ſuch Pounds, it is plain, that the whole Blood paſſes thro' the Heart 24 times in an Hour, that is to ſay, 576 times in a Day and a Night.

Now

Now if we should maintain with Dr. *Lister, p.* 47. that there are 75 Pulses in a Minute, or 4500 in an Hour; and that the bare Blood only, which circulates thro' the Heart, without including other Humours, as the Gall, Spittle, *&c.* which are separated from it, and do not circulate with it, consists of no more than 7 Pounds, as is pretended by some, the same will pass thro' the Heart at least 80 Times every Hour, if he allows 16 Ounces to the Pound; and above 100, if but 12 Ounces; but let the Difference be what it will, it is certain it goes thro' it a great many times.

SECT. VII. *Convictions from the foregoing Observation.*

LET now an unhappy *Atheist* sit down by himself, and fix his Thoughts upon the surprising Swiftness of the Blood's Motion: let him consider, how great the Strength of the Heart and Arteries must be, which, during the whole space of his Life, produce such a swift Stream of Blood: let him represent to himself the various Position of such numberless small Branches of the Veins and Arteries thro' which it flows; and having reflected upon the Misfortunes that happen to a Man, in case this Circulation is stopp'd even in the very smallest Branches, and particularly, that all this is brought about in his Body, without any Power of his own Will, and even without knowing or being sensible of what passes: let him ask himself, whether he can, with a consenting Conscience, maintain, that this whole Structure of the Heart, Lungs, Veins and Arteries, was not produced by a wise Master? and whether this Blood can be carried about so many thousand Times, for the space of 40, 50, 60, or more Years, through such narrow Vessels, and never cease moving, unless it be by the Direction of a Powerful and Gracious Ruler, who preserves and supports his Life, without the Assistance of any concurring Creature?

SECT. VIII. *Several Particulars.* 1. *Orifices of the Lateral Branches.*

THAT we may not be too tedious here, we shall pass by innumerable Particulars, which might prove a Powerful, Wise, and Gracious GOD, even to the blindest of Men; and only hint at a few, for the further Conviction of those deplorable Philosophers.

Dissect a Vein or an Artery, length-wise, and observe how regularly the Orifices in both of 'em lye; thro' which, from the latter, the Blood passes into the Branches that spring out of it, and from the former is received into the Vein ont of the Branches thereof.

SECT. IX. 2. *The Arteries grow narrower.*

CAN it be imagined, especially, that it comes to pass by Accident, that the Arteries are larger next the Heart, and gradually narrower, and divided into numerous little Branches, as they go farther from it? The Reason of which is, to prevent the Blood, which issues with so much Violence out of the Heart, from passing by the Lateral Branches, and following its way only in the large Vessels; for if that should happen, the Parts which lye on the Sides, would not be sufficiently provided with their Share of the Nourishing

riſhing Blood, and ſo would wither or periſh: For it only comes to paſs, by this narrowing of the Arteries, that the Blood flowing from the Heart, puſhes forwards all that it finds in the Artery, to make place for it ſelf; but that not being able to paſs ſo nimbly becauſe of the Straitneſs of the extreme Branches, preſſes every way upon the Sides of the Artery, and expanding the ſame (which is the Cauſe of the Pulſe) ruſhes into the Lateral or Side-Branches with more force than if the Artery had been every where of equal Bigneſs, or of greater than it had at its Beginning.

And muſt not every Body confeſs, that he can, as it were, feel with his Hands our Great Creator's End and Deſign in theſe Orifices that are found in the Arteries, and out of which the Side-Branches ſpring, if he has ever ſeen the Obſervations of that exact Anatomiſt *Lower*, in *Tab.* III. *Fig.* 6. where at *o b c d*, the Great Artery coming out of the Heart at *o*, and the Branches ſpringing out thereof, *a a a*, making the *Cervicales* and the *Arteria Subclavia*, are repreſented. Now if the Blood were protruded from *o*, through *b* and *c*, to *d*, it would paſs by theſe Branches, by reaſon of the wideneſs of the Artery, at leaſt, there would be leſs Blood communicated to them than was requiſite; for which reaſon the Great Creator has placed ſuch Protuberances at *c*, on the ſide of the Orifice, as may in ſome meaſure ſtop the Paſſage of the Blood in its way from *o*, thro' *c* to *d*, and cauſe it to turn its Courſe into theſe Branches. Can any one here likewiſe deny a *Deſign*, and think that all this comes to paſs by *Chance!* Why then does not the ſame Phænomenon occur in all other Branches, tho' wanted there?

Sect. X. 3. *The Arteries contract themſelves.*

But altho' the Blood that comes out of the Heart, does acquire a ſufficient Swiftneſs by the Contraction thereof, yet there ſeemed to be danger that the Heart expanding it ſelf, in order to receive New Blood, two pernicious things might happen, *viz. Firſt*, That the Blood might by its Weight fall back into the Heart; and, *Secondly*, that the Contractive Faculty of the Heart ceaſing, the Circulation of the Blood might likewiſe be ſtopped.

How the former is prevented by Valves, has been already ſhewn, when we treated of that Matter; and as to the latter, can any one imagine that it happens by Chance and without Deſign, that in the Arteries themſelves, where they have any Largeneſs, the Membranes of which they are made up (much like what has been ſaid about the Throat) have, beſides the Tunic A, (*Tab.* III. *Fig.* 7.) thro' which the Blood-Veſſels for the Nouriſhment of the Artery, and the Nerves particularly run, and B, where there are many little Glands, ſtill another Tunic C, which conſiſts of ſeveral Annular Fibres lying upon one another; and under theſe the Fourth, D, which is Membranous, and provided with long Fibres running ſtreight forwards, which are thicker, and more fleſhy near the Heart.

Now when the Artery is filled by the Blood that comes out of the Heart, to the end, that the Circulation ſhould not be obſtructed, theſe Annular Fleſhly Fibres contract themſelves, and ſo make the Artery narrower on all ſides; by which means the Blood being prevented from going back to the Heart,

Heart, is forced to proceed forwards and side-ways, and thus the Circulation of the Blood is inceſſantly continued, even while the Heart is open, and cannot protrude it.

Does not all this *Apparatus* of Inſtruments, which compoſe the Arteries, diſcover that they muſt have been formed by an underſtanding Artificer, who has adapted them all to wiſe Ends and Purpoſes?

Sect. XI. 4. *The Pulſe is not felt.*

Besides all this, foraſmuch as theſe Arteries ſpread themſelves thro' our whole Body, and at every time upon each Contraction of the Heart are expanded with ſo great a Force, and do Day and Night occaſion ſo ſtrong a Beating as we find by the Pulſes, who can conceive the Reaſon why we are not ſenſible of it as long as we are in Health, notwithſtanding that we may find them beat ſo ſtrongly in many Places, if we do but lay our Finger upon them?

'Tis true, that ſome lay it down for a Maxim, *De Conſuetis non judicat Anima*; that is, *Our Mind does not judge of that which we are uſed to do.* But if this were true, we ſhould judge as little of our *Reſpiration* as of our *Pulſe*, being accuſtomed as much to the one as to the other; and yet we find, tho' we often breath without thinking of it, that with never ſo little Attention we can perceive the Motion of the Air in our Mouth, Noſtrils, Wind-pipe, and Lungs, and diſcover from the Action it ſelf, that we breath; whereas, on the contrary, let a Man that is in good Health attend with as much Care as he can to the beating of his Heart and Pulſes of his Arteries, he ſhall not perceive them in the leaſt.

Does there not then appear, in a very particular manner, the Wiſdom and Goodneſs of our Great Creator in this matter likewiſe, who, that the Attention which we ought to give to other things, might not be diſturbed by this continual Pulſation, has been pleaſed to render us inſenſible of it? And tho' an Atheiſt cannot, or will not, ſee this, yet whoever acknowledges a God, may learn from thence, that it is his Duty to fix his Thoughts upon his Maker and his Works, who has ſo graciouſly wrought this Wonder in him, to the end that his Attention ſhould not be drawn away by this continual beating of the Arteries.

Nor can any aſcribe this to any material Property of the Arteries themſelves, foraſmuch as every Body is but too ſenſible, to his own Damage, of all theſe Beatings, when in a Fever, or other Diſtempers, the Fibres are extended by the Blood more ſtrongly than uſual. The ſame may be obſerved particularly, when in great Diſorders and Frights the Annular Fibres are contracted more narrowly, and after a cramping manner, than they ought to be, by the irregular Motions of the Humours of the Nerves which move the Arteries; ſo that theſe Veſſels being become ſtreighter, the Violence which they ſuffer from the Blood iſſuing out of the Heart, is more ſenſible than uſual. This is known to them that have heard the Complaints of ſome Women, who (as it is ſaid) being ſubject to ſudden Diſorders upon the leaſt

Accident, do many times feel their Arteries beat throughout their whole Body.

I don't know whether it may be useful to add here, that the Contraction of the Arteries, and other Parts of our Body, upon the account of Frights, seems in some measure to be confirmed, because in such great and Heart-affecting Motions, the whole Body is often put into a cold Sweat, which is known to proceed from the Contraction of the Glands in the Skin, that are thereby forced to protrude their Moisture; and if there be any small Hairs planted in these little Glands, they will rise up on end by the Contraction of the same; which Phœnomenon People may have often observed upon a Fright, not only in themselves, but in Beasts too.

SECT. XII. 5. *The Concurrence or Conjunction of the Veins.*

IF it be not owing to the Wisdom of the Creator, that there is no Part in the whole Body to which the Blood does not extend it self, and from whence it likewise returns; how comes it to pass, that Arteries meet Arteries, and Veins meet Veins so frequently, and discharge their Blood into each other, to the end, that in case any of 'em all should be disabled by Amputation, Obstructions, or otherwise, the Blood might pass another Way to or from the same Place?

SECT. XIII. 6. *The Division of the Arteries into Capillary Tubes.*

TWO Things more may be observed, touching the Circulation of the Blood thro' its Vessels; in which, no less than in the foregoing, the Wisdom of our Adoreable Creator shines out as clear as the Sun at Noon-Day.

The first is, that from the strong and swift Motion of the Blood in such Arteries as are large, there seems to be a Danger, that by reason thereof the Blood cannot contribute any thing towards the Nourishment of the Vessels themselves thro' which it runs so fast. Can one consider then without Amazement, that, to obviate this Inconvenience, the Arteries are divided in those Places where this Function is required, into an unspeakable Number of fine and narrow Tubes, which the Anatomists, by reason of their Smallness, are wont to call *Vasa Capillaria*, or *Vasa Minima*; that is to say, Vessels that are as small as a Hair, and so little, that they cannot therefore be described among the Arteries in *Tab.* III. *Fig.* 4. and all this to the end, that by passing thro' these *Defiles* or By-ways, and sticking to the Sides of such narrow Vessels, the Blood might proceed more slowly where it is necessary that it should do so, whilst that which passes thro' Vessels something wider, may pursue its Course to the Veins with greater Swiftness.

SECT. XIV. 6. *The Narrowness of the Tubes lessens the Swiftness of the Blood.*

NOW that a fluid Body protruded with the same Strength, runs more slowly through narrow than wide Pipes, for the above-mention'd Reasons, is well known to all Fountain-Makers, who can make the Pipes, through which the Water is to pass, so narrow, that by the sticking of the Parts of the Water to the Sides thereof, the Stream shall not rise near so high as it would do thro'

thro' larger Pipes: And if any Body doubts this, he may have an ocular Demonstration of it, by the following very easie Experiment.

Let him take the Glass Tubes E F G, of different Bores (*Tab.* IV. *Fig.* 1.) of those we made Use of (as I find it upon my Notes;) one of 'em E, was a narrow Neck of a broken Thermometer; the Second F, was something larger, and about the size of the Tube of a Barometer, or the Quill of a Pen; the Third G, was so large that one might thrust ones Finger into it. Then let him tye a little Thread about each of 'em at H, K, M, so that their Parts H I, K L, M N, may as near as possible be of equal length; and putting them into a long Glass, A B C D, which is filled with Water up to A B, let their lower Ends, I L N, reach almost, but not quite to the Bottom D C, in such manner, that the Threads H K M, may be even with the upper Surface of the Water: Then if he stops these Tubes with his Finger, at E, F, G, and thrust them (being empty, or rather full of Air) one by one, perpendicularly down into the Water, and suddenly remove his Finger from the Orifice, he will see the Water in the narrowest Tube E, rise up even with, yea, visibly above, the Superfices of the External Water H: Whereas in the Tube F, the Water will rise up as high as O, and in the Tube G, yet higher to P. Now those that are skilled in *Hydrostaticks* know, that equal Parts of Water lying in the Horizontal Superficies Q R, which passes under the Orifices of the three Tubes I, L, N, are pressed upwards with equal Force; and therefore, that the lesser Force, which appears in the ascent of the Water in the narrowest Tubes, must only be ascrib'd to the greater Narrowness thereof.

Now whether the Curvity of Angles, made by these little Branches of the Arteries; as also, whether their Multiplicity (so that being taken together, they may by reason of their Numbers, have more Wideness than the great Artery alone) do contribute any thing towards the slower Motion of the Blood, we shall not enquire farther here.

Sect. XV. 7. *The Veins grow wider.*

The *Second* thing is, That in case the Blood, which thro' larger Vessels runs swiftly along the Arteries, should retain the same swiftness in the Veins, by which it is carried back again into the Heart, there would be danger, that the Heart should be overflowed with too much Blood, and the Right Ventricle of it filled so full, that it could not be able sufficiently to exert its contractive Faculty.

Now to prevent such pernicious Swiftness, could any Body have thought of a wiser Expedient, than to have made these Veins larger and larger, as the Blood came nearer from the Extreme Parts to the Heart, as may be seen in *Tab.* III. *Fig.* 5. quite contrary to the Arteries, which in *Tab.* III. *Fig.* 4. grow continually smaller from the Heart to the extreme Parts.

Now that a Liquor passing thro' a narrow Vessel into a wider, runs slower in the same space of Time, is obvious enough to every one, without proving it experimentally; but if he has a mind to see it that way likewise, let him fill a Pipe with Water, and thrust it with its Orifice downwards, into a Bucket, which has likewise Water in it to a certain Heighth, and forcing

the Water as fast as he can out of the said Pipe, he will find, that the Water in the Bucket will ascend but to a very small Heighth, tho' all that was in the Pipe came out of its full Length at the same time; from whence it appears, that the Water in the narrow Pipe moved more swiftly than that which was in the wider Vessel: But this is so plain, that we need say no more of it.

Sect. XVI. 8. *The little Valves in the Veins.*

But since the Blood moving more slowly in these Veins (*Tab.* III. *Fig.* 5.) might, by reason of its Weight, (especially in those that carry it directly upwards) endeavours to sink down or go back, and so in long Tubes forcibly resist this slower Motion; may we not again discover here the Providence of the Creator, exerting it self in so peculiar a manner, who has thought fit to place little Valves in these Veins; sometimes but one, as in *Tab.* IV. *Fig.* 2. at A; sometimes two together, as at B B, whose Business is to stop the Blood when it attempts to go back, and that in may not, by its Weight, press too much upon that which follows, and thereby retard its Motion?

Now is all this done by Chance, and without Design? Why then are these Valves fixed in the Veins, where they are so serviceable, and not in the Arteries, where they are so far from being necessary, that they would be prejudicial?

Sect. XVII. 9. *Of the Fibres in the Veins and Arteries.*

We must add one thing more, and so conclude these Remarks, which would otherwise, as is well known to those that understand it, swell to a much greater Bulk: Can any rational Man then perswade himself, that the Great Creator had no End at all, or that it came to pass merely by Chance, that in the Arteries, where the Blood stood in need of more strength, in order to insinuate itself into the narrow Passages of their extreme Branches, the Muscular Fibres, by which they are contracted, are very strong in those Parts; and on the contrary, in the Veins, which continually grow larger, and in which too great a Swiftness and Contraction would be hurtful, the Fibres are far from being so strong or so numerous? But that which the Wise Creator causes us to feel as it were with the Hand, is that in the *Vena Portæ*, the like Fibres are again stronger than in other Veins, tho' fewer than in the Arteries; those being the only Veins of all those of the Body, whose Branches, entring into the Liver, grow narrower and narrower; for which reason they require more Strength than other Veins, to the end, that like the Arteries, they may oblige the Blood to pass on to the narrow Ramifications, and to the Glands of the Liver.

Sect. XVIII. *The Uses of the Blood in General.*

Now to pass by other Particulars concerning the Blood and Veins, of which we have already treated very fully, the Thread of our Discourse seems to lead us to the Uses and Motions of this Blood.

There-

There are Three particularly, that, among others, are known to depend either wholly, or in part, upon the Blood: The *First* is the Separation of so many different Humours, which are either necessary to the Body, or must otherwise be discharged. *Secondly*, The Nourishment of the Body. *Thirdly*, The Motion of the Muscles.

Now whilst we are going to treat of the first of these in its order, let no Body think that we design to enumerate the various Opinions of many learned Men thereupon; being contented to shew the External Disposition of some, so far as it is known; since Men have not yet been able to penetrate all that belongs to it; besides, it was both out of our Power and Design too, to handle this Matter alone in this Place. A rough and general Account of the Uses of these separated Humours will be more than sufficient for our Purpose, which was to convince a Sceptical Mind, that we are formed by a GOD abounding with Wisdom and Goodness.

SECT. XIX. *The Enumeration of several Humours.*

NOW to pass over the *Lymph*, which is separated in so many Places, the Gall in the Liver, the Juices in the Pancreas, and in numberless other Glands, the Humours in the Stomach and Intestines, in the Eyes, Nose, Ears, Mouth and other Parts; forasmuch as there are still different Opinions about them and their chiefest Uses: Can one see that there is discharged from the Brain so Powerful and Spirituous a Humour, which is derived by the Nerves to all the Parts of the Body, rendering so many and such important Services, and being particularly the chiefest Cause of all our Motions; that there exhales from the Pores of the Skin, and by Respiration, an invisible and continual Vapour (supposing a Man to be in good Health) in so vast a Quantity, that the accurate *Sanctorius* has discovered, that this alone does exceed every day all the other grosser and visible Evacuations?

Can any Body believe, that it happens without a fix'd Purpose of our Great Preserver, in order to continue upon the Earth the Race of Mankind in their Children, that the *Materia Seminalis*, for the Procreation of them, is separated from the Blood; and that the Milk flows from the Breasts of the Females for the Nourishment of their tender Sucklings? Can any Body contemplate the Dispositions of the Water-Courses, when the Blood is separated from its Salts in the Kidneys, without discovering the Finger of his adoreable Creator in all these Things?

SECT. XX. *The Passage of the Urine.*

AND to the end that all that has been here said may not pass for Declamation, or Rhetorical Figures, let us examine a little more closely the Dispositions that are made in the solid Parts of the Body, for these three last mention'd Humours; without enquiring into that great and wonderful Mystery, how each of them has acquired its peculiar Faculty or Property, which hitherto remains among the Secrets of the Great Creator.

Now to give some Notion thereof to an unexperienced Person, let him suppose, in *Tab.* IV. *Fig.* 3, that the Blood descends from D to *u*, thro' the Great

Great Artery D *u*, of the Heart; and because the said Artery at *u*, and in the farther proceeding Branches, grows continually narrower, that the said Blood is forced to pass into the Side Branches; by which means it takes its Course thro' one of them, called the Emulgent Artery F, to the Kidney B, where having discharged its Salts, it returns by the Emulgent Vein W, and so proceeds by C, along the *Vena Cava* upwards, again to the Heart.

In this Kidney (the internal Structure of which is represented *Tab.* IV. *Fig.* 4.) the Humour of which the Urine is composed, seems to be separated in the outmost Glandulous Substance, A A: Do we not here, without going any farther, perceive the wonderful Operation of the Designs of the adoreable Creator, who makes this Humour descend thro' such narrow Vessels B B, which being collected into a kind of little Nipples, called by the Anatomists *Carunculæ Papillares*, do filtrate this watry Matter with its Salts into larger Membranous Vessels, *c c c*; which do again discharge what they had received, for the most part, into two great Spaces, out of which there is made one great one, C, called the *Pelvis*; thro' the Orifice thereof this Liquor descends farther into the Tube D, or the *Ureter*, which being joined to the *Pelvis*, do represent a compleat Funnel with its Pipe, which being inserted at Y Y, (*Tab.* IV. *Fig.* 3.) in the Bladder H, makes on each side a Vessel G Y, in order to discharge that which is brought into it?

Two things seem to be requisite here; *first*, that the Urine coming into the Bladder, may be driven out of it again; and, *secondly*, that in order to prevent Inconveniencies, it should not happen continually, nor without our Will. Nor can it be imagined, that it is without Knowledge and Design, that there should be Muscles likewise placed in the Bladder, in order to contract it, and force out the Water, besides the Muscles of the Belly which could have pressed it; and particularly, that tho' the Bladder were contracted and drawn together, that which is contained might have burst out at every Orifice, if it had not been so contrived that that Humour should not be able to return thro' the Orifice Y Y, by which it descended from the *Ureters* G, but only thro' that Passage which Nature has prescribed it?

Thus we see that it is easie to blow up the Bladder H, by one of its *Ureters* G Y, but if it should be blown by that Tube, thro' which the Urine comes out, the very Children know, that the Wind cannot pass that way thro' the Orifices of the *Ureters*.

And as for what relates to the second thing, we may observe, that the Bladder is fortified with a strong Muscular Valve at the lower end of it, to prevent the Leaking of its Humour, and is shut up by the same till a greater Force obliges it to give way, and suffer the Water to pass thro' it.

Add thereto, that because this Humour is almost always Salt, and often sharp, the most gracious Care of our Creator (to the end, that it should not corrode the innermost Membrane of the Bladder, which is exceeding sensible, and so occasion Pain) has fortified the same with a kind of a tough and slimy Moisture against it in the inside.

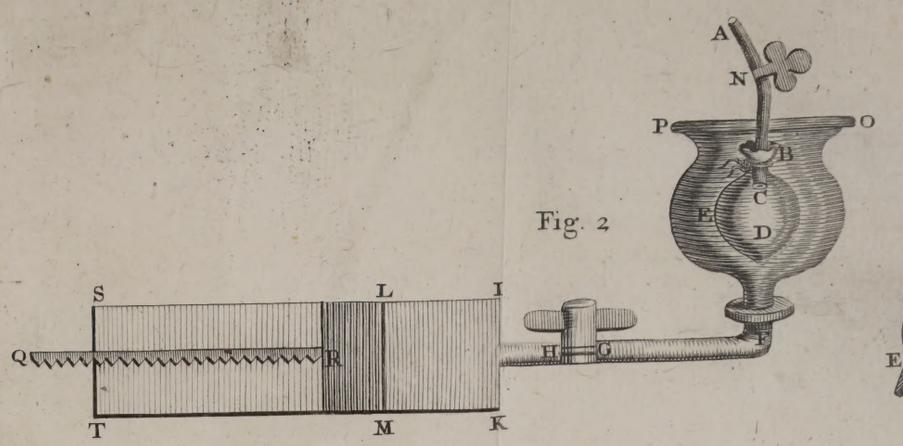


Fig. 2

Fig. 1

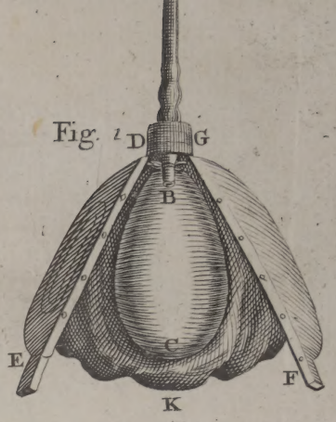


Fig. 5.

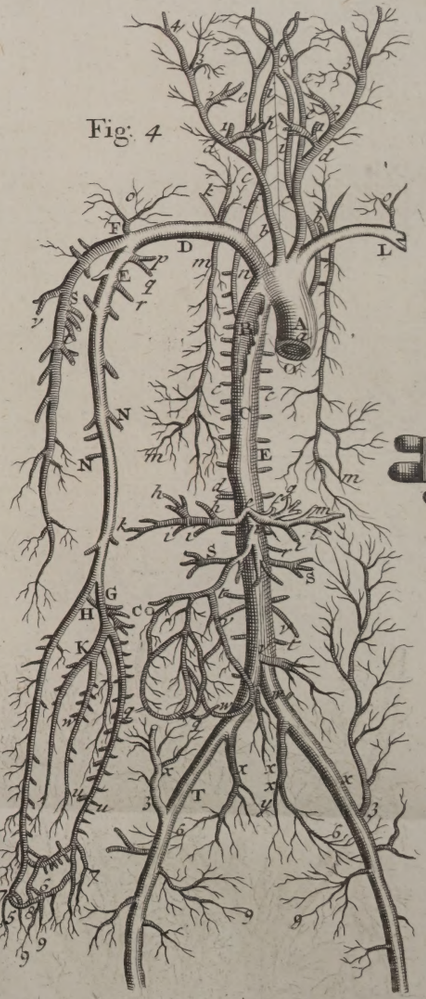


Fig. 4

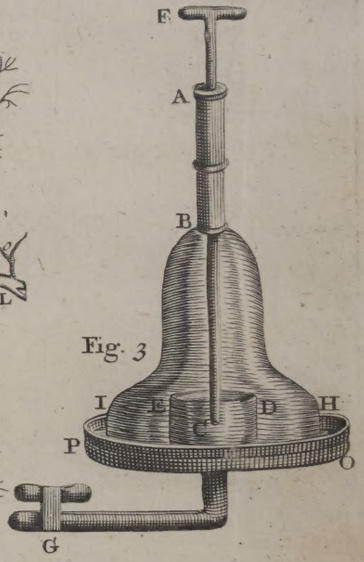


Fig. 3

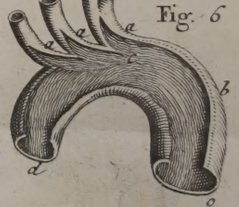


Fig. 6

Fig. 7

Sect. XXI. *The Breaſts of Women.*

The ſame Wiſdom appears in the adapting other things to their Ends, ſuch as the Tubes of the *Ductus Salivales*, and eſpecially in the Structure of thoſe Ducts, by which the Gall paſſes from its Bladder, and from the Liver to the Inteſtines; and the Veſſels of other Parts, where the Humours are ſeparated from the Blood.

But can he, who ſees no more than the little Glands A A, in the Breaſt of a Woman (*Tab.* IV. *Fig.* 5.) (the external Tegument being taken off) in which the Milk is ſeparated from the Blood; and the little Tubes *b b*, into which it flows, and where it is preſerved, to the end, that it may in proper time be ſuck'd out thro' the Nipple C, where they are open, and in which they terminate: I ſay, can he that ſees theſe things imagine, that this only part, to deduce no Arguments from all the reſt, had not a Maker, who deſtined it to perform a Service ſo very important to all Creatures in their moſt tender Age?

Sect. XXII. *The Structure of the Seminal Veſſels.*

Now that every one may be yet farther convinced, that all the Parts of of our Body are with great Wiſdom adapted to particular and certain Uſes; let us go on, and conſider the other Parts repreſented in *Tab.* IV. *Fig.* 3.

1. How the Spermatic Arteries P P, coming on each ſide out of the Great Artery D *u*, do deſcend to the Teſticles, therein to diſcharge the Seminal Matter which they bring thither with the Blood, the Remainder of which is carried back again from the Teſticles to the Heart by two Veins O and *n*, and with how many Windings and Turnings the ſame aſcend, may be ſeen on the left Side *o o*, where they are repreſented as ſtretcht out; whilſt the Artery P, deſcends ſtreight forwards in a Man, as *Verheyen* has obſerv'd.

And, that we may all ſee that the Wiſdom of our Creator extends itſelf to the meaneſt Things, it need only be remark'd, that the Arteries P P, do, for the moſt part, proceed immediately from the Great Artery D *u*; but that the Veins O and *n*, thereto belonging, do not both, but only one of 'em, *viz.* O, and on the Right, diſcharge itſelf into the *Vena Cava* C *u*, whilſt the Left *n*, is inſerted into the Emulgent Vein W, becauſe it was to be feared, that as it took its way into the *Vena Cava* C *u*, the Courſe of its Blood might be obſtructed at every ſwelling of the Artery, by reaſon of the continual Pulſe of the Great Artery, over which this Vein muſt have neceſſarily paſs'd, as appears by the Figure; ſo that by this Conveyance of the Blood from *n* to W, and from W to C, (which otherwiſe, if it ran as at O would be ſhorter) this Inconvenience is prevented by a careful Providence, and it is fully prov'd, that it intervenes in ſo ſmall a Matter as the Courſe of this Vein.

2. That in order to bring the Seminal Matter, ſeparated from the Blood in the Teſticles, to its deſtin'd Place, two Tubes, R R, or *Vaſa Deferentia*, aſcend from the ſaid Teſticles, and carry the Seed into the *Veſiculæ Seminales*, which

which appear on one Side behind the Bladder X X, and there it is preserv'd till the time of its Use.

3. That the End of these Seed-Vessels is stop'd by little Glands, which prevent the Matter from distilling out of its own accord, and yet do not obstruct the same when Ejection is necessary.

4. That in each of the Groins there is a peculiar Tube made for that purpose, of the Membrane that lines the Belly, call'd the *Peritonæum*, thro' which the Seminal Vessels, or *Vasa Præparantia*, O P descend, and the Seminal Ducts, or *Vasa deferentia*, R R, ascend; as may be seen *Tab.* II. *Fig.* 1. W W.

And particularly, to prevent the Intestines from pressing into the *Scrotum* or Cod, and causing what we commonly call a Bursten or Broken Belly, these Tubes are cover'd with a Membrane in *Men*; but in Dogs, and other Creatures, whose Posture is not erect, and consequently which are in no danger of such Accidents, the same Tubes have no Covering, but are quite Open.

SECT. XXIII. *Convictions from the foregoing Observations.*

THERE are whole Volumes written to shew all the Particulars of these Parts only; we shall therefore go no further, but leave it to every one that Reads and Understands what has been already said, to examine himself, whether he can believe, that in all these Matters about the Seed, Bladder, Breasts, *&c.* the Wisdom of a Creator has had no Room; and whether he can admit, that among thousands of Differences, any one of which, in case all things had been produced by Chance, and without Understanding, might have here equally come to pass, these only should have taken effect; all of which are so well adapted to such Great and Necessary Purposes? I can't forbear saying one word here likewise to some other Philosophers, and observe, that since, as we have just now shewn in *Tab.* IV. *Fig.* 3. the Spermatic Vein *n*, on the Left Side, does not take the shortest and most simple way to the *Vena Cava* C *u*, as that on the Right Side does in O; but making a Tour, does first insert and discharge itself in the Emulgent Vein W; that it is in vain to affirm, that those Hypotheses carry the greatest Truth with them, which appear to us to be the most simple, and to produce every thing after the shortest Manner; forasmuch, as there may be unknown Reasons, as here in the Case of the Great Artery D *u*, why the Supreme Architect, in order to bring about his other Purposes, may think fit to depart from that Method, which would otherwise be more short and simple in the Production of that End only.

SECT. XXIV. *The Nourishment and Motion of the Blood, not yet fully known.*

NOW it would be time to pass on to the other Uses of the Blood, namely, the *Nourishment* and *Motion:* But forasmuch as the Ways of the Great Creator are in these Matters, even to this time, inscrutable to us, and that the Structure itself of the solid Parts are not yet fully known, but do abound with Disputes; we judge it more safe to be silent therein, than purposely to offer only Guesses and Uncertainties, or Positions, which are not yet sufficiently

ently received by Learned Men, how probable soever they may seem; the Adoreable God has not however left himself without a Witness, to every one that seeks him, in numberless other Matters, the Certainty of which, can by no means be called in Question.

CONTEMPLATION IX.

Of the Nerves, and briefly of the Lymphatick Vessels, Glands, and Membranes.

Section I. *The Transition to the Nerves.*

WHEN we were treating about the aforesaid Separation of the Humours of the Blood, it would have been proper enough to have mention'd those of the Brain and Nerves, as a kind of Humours; but with respect to our Design, the so important Use thereof, the so wonderful Texture of the whole Series of the Nerves, which, like the Arteries for the Blood, serve for Vessels to convey these Humours; they are by much too considerable to be handled cursorily, without saying something particular of them too.

Now then, in order to convince an unhappy Philosopher, of the Perfections and wise Designs of his Maker, nothing more seems to be required, than to move him to look into the Enquiries and Observations of the Anatomists, and especially of *Willis* and *Vieussens*, and endeavour to acquire a just Idea of the Concatenation of this wonderful Structure, of the innumerable Multitude of the little Branches of the Nerves, of which there is not one that is made, but what is of great and peculiar Service to the Body.

To represent something of this Matter here, let him cast his Eyes upon *Tab.* IV. *Fig. 6.* and consider, if each of these fine Branches performs its Function, (and some of 'em are so very necessary, that if they cease, they put an end to our Lives;) whether these Nerves that appear to the Eye of an unexperienc'd Person, so irregular and confused, and yet in themselves are so well disposed, that there is not one of 'em, yea, not the smallest Branch or Sprig of 'em but has its Use; let him consider, I say, whether all this can be performed by Chance? He that desires to be more fully convinced hereof, let him consult the large Figures of Mr. *Vieussens.*

Sect. II. *Different Opinions about the Matter that passes thro' the Nerves.*

It was well enough known to the Ancients, that all the Nerves are a kind of Vessels, thro' which a certain Matter, that descended from the Brain into the Muscles was either an entire, or at least a concurrent Cause, of their Motion: Because, if a Nerve was cut off, obstructed, or otherwise disabled, the

Muscle to which it belonged, notwithstanding all Endeavours to the contrary, would remain without Motion.

This Matter is conceived by all to be indeed fluid; but by some 'tis supposed to be a Wind or Spirit, and is therefore called the Animal Spirits, and is believ'd to pass thro' the Nerves with a Swiftness like that of Lightning; it being otherwise impossible to reconcile the unconceivable Quickness of the Motion, which we see performed by Creatures in so short a space of Time, with the slow Course of a Liquor: Upon this Foundation, there are supposed to be Valves, and many other things in the Muscles, in which Suppositions there is Ingenuity enough, if there were but enough of Truth too.

But these Opinions are called in Question; *First*, because it has been sufficiently proved by Chymical Experiments, that so very volatile a Matter is not always required towards the producing a swift and violent Motion; accordingly, it has been seen, that by the Mixture of Oyl of *Vitriol*, and Salt of *Tartar*, the first of which has little, and the other hardly any Volatility in it, a strong and sudden Fermentation has been produced. We are taught by a like Experience too, that Salt-petre, Brimstone, and Charcoal, which are not counted among volatile things, being mingled together into Gun-Powder, have occasion'd such Motions, as for Swiftness and Force, have not yet been equal'd. The same appears from the Glass of Antimony, which being a fixed Body, (or at least so little volatile, that it is able to resist a very strong Fire for a long time, as is well known to the Chymists) has yet the Faculty of producing such great Commotions and Contractions in Humane Bodies, even so small a quantity of it, that those who have tried, it own it to be wonderful: Others deduce the Motions of the Muscles from Hydrostatical Laws, which therefore need not suppose so great a Swiftness of the Nervous Juices.

Secondly, the Course of the Nerves being now better known to the Anatomists, it has been discover'd by the Complaints of their Patients, that it was probable, that a slowly moving Matter passed thro' the same; which seemed to be in some manner more credible when it was consider'd how improper the moist Substance of which the Brain and Nerves are composed, appear to be for affording a free Passage to any thing that was to move thro' them with so unconceivable a Swiftness as the matter of Wind and Spirits.

Sect. III. *An Experiment to prove a Nervous Juice.*

But particularly the Experiments taken afterwards by Messieurs *Bellini* and *Malphighi*, seem to have put the Matter beyond Conjecture, and to prove, that there is a tough Humour (which they called *Succus Nervosus*, or the Nervous Juice, in opposition to the *Animal Spirits*) which run thro' the Nerves.

For if you dissect the Breast of a Creature, in which there is still a little Life, or that is but just Dead, and with the Fingers of one Hand, press the Nerve of the Midriff in such a manner, that nothing can descend from the Brain into it by this Vessel; and after that go on to press with the other Hand that Part of the said Nerve, which is between the first Pressure and the Midriff, so as to drive whatever it contains forward into the Midriff; it will be found, that the Midriff will resume the Motion which it had lost, and continue

tinue it till the Humour that was in the Nerve be quite protruded: But if you looſen the Fingers of the Firſt Hand, and admit a New Paſſage to that which comes from the Brain, you will ſee, after ſome time, that, as ſoon as this New Humour reaches the Midriff, the Motion of it will be renewed. Conſult *Bergerus* upon the ſame, *Page* 260. And, that one may have ſome ſolid Foundation that the Matter of the Nerves is of the Nature of a Liquor, and not of a Spirit or Wind, the great Enquirer, *Malphighi*, has ſhewn, that by preſſing the End of the Great Nerve in the Tail of an Ox, the ſame will ſwell before your Finger; and if you make an Inciſion in it, there will come out a viſcous Liquor like Turpentine. Which Experiment having been ſeveral times proſecuted by *Bergerus*, and always appearing in the ſame manner, it puts the ſaid Hypotheſis out of all Doubt.

SECT. IV. *Convictions from the foregoing Obſervations; and an Experiment about Motion.*

I WOULD ask any Body now, that underſtands this, whether it can ſeem credible to him, that it is brought about by Chance only, and not for any Wiſe Purpoſe, that a Humour, which is ſeparated from the Blood in the Brain, is derived into every Part of the Body, by ſuch an innumerable multitude of Tubes and Channels, in order to produce Motion wherever it is requiſite? To ſay nothing here of the Fermentation of the Food, of Nouriſhment, and ſo many other Uſes, which render the Courſe of this Nervous Juice entirely neceſſary: And can it be without an End, that this Humour has one wonderful Property, (more we cannot reckon here with any Certainty) that it is fitted, together with the Blood of the Arteries, to produce theſe Motions in the Muſcles?

For that the Arterial Blood does likewiſe very much contribute to Motion, may appear from the Experiments of *Bartholinus*; by which we ſee, that a Limb or Joynt is render'd lame and void of Motion, as well when, by Binding the Artery, the Blood is hinder'd from coming into the Muſcles, as when the ſame is done to a Nerve. And can any one obſerve this come to paſs, after ſuch an amazing manner, not only in one, but in all Men and Beaſts too, and ſo many Wonders produced thereby; ſuch as the external Motions of Walking, Swimming, Flying; and the internal, of the Heart, Arteries, Stomach, Bowels, and ſo many other Parts, ſerving both for the Support and Procreation of Animals; and can he then aſcribe all this to meer Chance and ignorant Cauſes, without thinking that he will be taken by all wiſe Men for a blind or obſtinate Fool?

SECT. V. *The Nerves of Hearing are extended likewiſe to the Tongue.*

NOW let a Man conſider farther with himſelf, whether the Great End of our Creator, to furniſh us compleatly with every thing that is neceſſary for us, does not plainly appear in the following Caſes: *Firſt*, That the Nerves of *Hearing* do diſtribute their Branches to the Muſcles that move the Ear, to the end, that as ſoon as we are warned by the Noiſe which affects the Nerve, the other Inſtruments may be immediately put into a Condition of erecting

the Ear, in order to liſten the better: This is obſervable in the raiſing the Ears of many Creatures as ſoon as you ſpeak or call to them; for the ſame Reaſon it is, that this Nerve ſends other Branches to the Eyes alſo, that upon the hearing of any uncommon Sound, we may preſently look about us; and likewiſe, be ready, without delay, if ſpeaking or calling for Help be neceſſary; for which purpoſe, the ſaid Nerve of *Hearing* has a Communication with thoſe of the Fifth Pair, and the Parts that produce Speech.

Sect. VI. *The Nerves of Taſting.*

Secondly, That the Nerves which ſerve to produce *Taſt*, and which, according to *Willis*, make a fifth and ſixth Pair, do likewiſe ſend out Branches to all thoſe Inſtruments that are neceſſary for Maſtication or Chewing, to render the Action and Taſt lively and ready; they likewiſe ſend other Branches to the Noſe and Eyes, to the end, that in the Choice of our Victuals, we may be aſſiſted by the Smell and Sight: And laſtly, that while all the forementioned are exerted, to the end, that nothing may be wanting, other Branches are tranſmitted to the Glands for Spittle, that this Humour may be ſupplied in abundance, and the Mouth and Throat moiſten'd therewith, during the Action of Chewing and Taſting.

Sect. VII. *Nerves that Operate with or without our Conſent.*

Thirdly, Can any one ſee, without Aſtoniſhment, that Nerves, which ſeem to be made of the ſame Matter, and maintained by the ſame Food, can perform ſuch various and different Functions? That the firſt, which comes out of the Marrow of the Back, as the ſaid Spinal Marrow does from the forepart of the Brain, ſhould entirely be governed by our Will, in the Motions produced by it in our Arms, Legs, *&c.* and accordingly cauſe the Muſcles to operate, or to ceaſe Working; whereas the other, that have their Origin in the *Cerebellum*, or Hinder-part of the Brain, do continually and inceſſantly move thoſe Parts to which they are tranſmitted, as long as our Life laſts, without the leaſt Subjection to our Will.

Sect. VIII. *The Par-vagum and Intercoſtal Nerves.*

We ſhall give a Proof hereof, in *Tab.* IV. *Fig.* 6. which, by reaſon of its Smallneſs, can only ſhew us a little of it: A B is the *Par-vagum*, or Wandering Nerve, as it is called by the Ancients, becauſe it is extended to ſo many Parts; by *Willis* it is called the Eighth Pair; of this, A repreſents the uppermoſt *Plexus*, and B the following; after ſome Ramifications to the Muſcles of the Throat and Neck, there goes out of A, a Branch *a*, to the upper-part of the Wind-pipe, there come ſeveral other from B, which extend themſelves to the Heart, to the *Pericardium*, and to its Auricles and Blood-Veſſels, and one bigger than the reſt, C, which runs to the *Plexus Nervoſus* of the Heart F; from the *Plexus* B, there ſprings likewiſe the recurrent Nerve D on the right Side, and E from the Body of the Nerve itſelf on the left Side, which moves the Windpipe

Beſides

Besides these, there goes at *e*, a great Branch to the Vein of the Lungs, and to the Heart at D, and from the *Plexus Nervosus* of the Heart F, runs a Branch *e*, to the Artery of the Lungs, and a great many, *f*, to the Heart.

Moreover, there pass from this Nerve a great many Branches *g*, to the Lungs, and the Veins and Arteries, and *Bronchi* of the Lungs in the same, and some, *h*, to the Gullet.

Finally, this same Nerve divides itself into two Branches, G H, on each side, which afterwards uniting again in I, spreads an unspeakable number of Branches in the Stomach; and, after having sent some Sprigs to the *Plexus Nervosus*, lying in the Belly, ends there, as far as we have been able to discover.

The fifth and sixth Pair of Nerves (marked 5 and 6) the first of which does in a manner furnish all the Parts of the Face and Mouth with Nerves, make a great Nerve by the Branches which they send out, and which are commonly called, tho' not very properly, the *Intercostal*; this, after having made a *Plexus* above at *i*, and transmitted out of it a Branch to the contracting Muscle of the Gullet, proceeds forward to a second *Plexus* K, which lies in the Neck; and after having sent out of it some Fibres ^, to the Gullet and Windpipe, communicates farther great Branches L, to the *Plexus Nervosus* of the Heart. Again, this same Nerve makes a third *Plexus* at N, and then descends thro' the Breast, where some Nerves, *n n*, are inserted therein from the Back-bone; and coming into the Belly, transmits to great Branches, P P, downwards, which makes other *Plexus* at S T U *u*, and from thence communicates Nerves to all the Intestines of the Belly, as may be seen in W, passing to the Bowels.

To conclude; There are none of the Entrails either in the Breast or Belly, but what receive Branches from the two Nerves we have here been describing; *viz.* the *Vagus* and the *Intercostalis*. Whosoever desires to see them minutely represented, may consult the famous Works of Messieurs *Willis* and *Vieussens*; whose Figures from Branch to Branch, together with the Course of the Nerves in the Body, before they were published, were compared and examined by another great Anatomist, being founded upon experimental Dissections of above 400 Bodies in the space of fifteen Years.

One might here make infinite Remarks upon each Duct, or Course, of these Nerves; upon their Insertions into one another; upon the several Parts which receive their Nerves from the said Branches; upon the *Plexus* that appear therein, and which consist of the Concurrence of many Nerves of a different Original; as at F, for Instance, which is equally composed of the Sprigs of the *Par-vagum* and *Intercostale*; to the end, that the Heart, which is thereby moved, might receive its Nervous Juice from the one, in case the other should fail: To say no more, can any Body imagine, that these Dispositions have been made without Wisdom?

Sect. IX. *Convictions from the foregoing Observations.*

I Cannot forbear putting this one Question to a Man, that is still so unfortunate, as not to be able to discover from all these things, the Wisdom of his Creator; *viz.* Whether he can, without trembling, consider, that all this

this great Compoſition of the *Wandering* and *Intercoſtal* Nerves, by which his Heart, Lungs, Veins, Stomach, Guts, Liver, Kidneys and every thing elſe, that contributes to the ſupport of his precious Life, are moved, is performed entirely without his own Will and Concurrence? And, that there is ſcarce any thing elſe left to him, beſides the Command over thoſe Nerves which ſerves for its External Functions; whilſt, in the mean time, he is not able to continue one ſingle Inſtant the Action of thoſe Nerves by which he lives. Nor can the moſt obdurate *Atheiſt*, or the *ſtrongeſt Mind*, (as they love to call themſelves) find here any Evaſion to ſatisfie his diſturbed Conſcience, that he is not abſolutely in the Hands of another, upon whom his Life does continually depend; at the ſame time that he is forced to confeſs, from his own Experience, that all the Motions contributing thereto, are produced in him, without, and againſt his Will, by Nerves, whoſe Operation he can neither directly obſtruct, nor promote.

Sect. X. *The unhappy Condition of the Atheiſts.*

How much more happy then is ſuch a one, who from Contemplating the Diſpoſition and Structure of his Nerves, and the Conſequences thereof, has learned to know himſelf ſo far, as to be experimentally convinc'd, that his gracious Creator has cauſed all the Nerves which ſerve for the ſupport of his Body, for the Motions of his Heart, Lungs, Stomach, *&c.* for the Circulation and Separation of his Humours and other Neceſſaries of Life, to operate for the reſpective Purpoſes, by an immediate Power; and not only without his Will, but even without his Knowledge, or any Perception thereof? And who having farther obſerved how many Nerves, by the wiſe Providence of his Maker, are ſtill left for the moving of other Members, according to his own Diſcretion wholly; I ſay, who is there, that after having ſeriouſly conſider'd all theſe things, does not find himſelf obliged to uſe them all to the Honour and Glory only of his adoreable Creator?

Sect. XI. *The Nerves of the Midriff.*

And if this be not ſufficient to convince every Man of the Views and Deſigns of a Wiſe and Merciful Creator, in the Diſpoſition of the Nerves, let him caſt his Eyes upon *Tab.* IV. *Fig.* 7. in which he will find the Repreſentation of the Midriff, which we have cauſed to be drawn for this purpoſe only.

Now to ſay nothing of its Circular Muſcle A A, and another B, its Tendinous Part C, the Paſſage D for the Gullet, and E for the *Vena Cava*; as alſo the Blood-Veſſels that feed it, G H I; of which every Body that underſtands their Uſes, can ſay a great deal more, in order to prove the Wiſe Deſigns and Purpoſes of the Great Creator: Can any one be ſo blind, who knowing how neceſſary it is, that the Motions of the Midriff ſhou'd depend upon our Will, when in extraordinary Breathing, in Singing, Speaking, and other Incidents, the ſame is requiſite, obſerves here, that two Nerves K K, iſſuing out of the Nerves of the Neck (as they do from the *Medulla Spinalis*) and therefore do belong to thoſe that are ſubject to our Will, are beſtowed upon the

the said Midriff? And when he is moreover convinced, that it is no less necessary that the great Work of Respiration should be continually carried on, even whilst we sleep; and how inconvenient it would be, that whilst we are waking, if we happen to fix our Thoughts upon other Matters, we should be obliged every time to attend to the Business of Respiration, and to divert our Thoughts from all other things to this alone: Can a Man, I say, without acknowledging the gracious Purpose of his Maker, observe that two other Nerves, L L, are communicated to the Midriff, which (as it happens also to the Bowels, Heart, *&c.*) do continue the Motion thereof without our Concurrence, and when we least think of it, and for that reason take their Rise from the Intercostal Nerves, which are made for that Purpose?

Sect. XII. *The Nerves of the* Intestinum Rectum.

The same may be observed, besides other Parts, in the *Intestinum Rectum*, which requires one Motion spontaneous and independent of our Will, in order to bring forwards that which is contained therein; and again, a second Motion, which is voluntary, in order to be exerted with the greater Force at the time of the Discharge.

The Words of the accurate Anatomist *Verheyen* are very remarkable upon this Occasion: *The Intestines have, among others, their Nerves of the great* Plexus Nervosus *in the Mesentery, and all of them are serviceable to the Motions performed without our Will* (Functiones involuntariæ.) *But the* Intestinum Rectum, *and probably also that Part of the Gut that is immediately joining to it, has other Nerves from the lower Part of the* Medulla Spinalis, *by the help of which the Discharges of the Belly are performed, according to, and in consequence of our Will.*

Sect. XIII. *The* Vasa Lymphatica.

Now as the Blood which goes thro' the Arteries to the Parts of the Body is brought back again thro' the Veins, the Enquirers into Nature have likewise asserted, and not without great Probability, that the Humour which is separated from the Blood in the Veins, and which is communicated by the Nerves to all the Parts, is brought back also by another sort of Vessels (called the *Vasa Lymphatica*) to the Blood, and so performs as it were another Circulation.

Now whether this *Lymph*, or transparent Liquor, proceeds from the smallest Side Branches of the Arteries, in each of which at the same time a Nervous Sprig discharges itself, we shall not here farther examine, but refer such as desire to know it, to the second Work of Monsieur *Vieussens*: This is true at least, that these *Vasa Lymphatica* or *Lymphaticks* are observed to proceed from all the Parts of Creatures (the Brain excepted, that being yet doubtful) as likewise that the Course of their Liquor in *q q* (*Tab.* I. *Fig. 6.*) proceeds to the *Ductus Thoracicus* O *r r*, and so to the *Vena Subclavia*, *u x*, and other Places directly to the Veins; that they have innumerable little Valves, in order to prevent the Return of the said Liquor, and so appear like Links of little Chains *q q*; that they touch upon several Glands in their Passage, or

proceed

proceed likewise from some. Those who desire to have any Notion of this Matter, may consult *Tab.* IV. *Fig.* 8. where it is shewn how these *Lymphaticks* L L L, *&c.* coming out of the Kidneys B B, and other Parts of the Body, have a Communication with the Glands F, G, H, I, K, and discharge themselves into the Receptacle of the Chyle D, in order to carry their Liquor on to the Blood by the *Ductus Chylicus* E, which is here represented as cut off, and in the mean time (as we have said above) help to make a Stream for the Circulation of the Chyle.

Now how unknown soever may be the true Source or Origin of these Vessels, forasmuch as most of the Experiments have been made upon Beasts, and described from them, the Opportunities being very rare of opening Men so quickly after their Death, in order to discover these Vessels which do presently disappear, for which reason some principal Anatomists have endeavoured to shew their Course by injecting Quicksilver, prepared for that Purpose, into them; yet this at least is true, that they do discharge all their Liquor into the Venous Blood, and so render the aforementioned Service to the Chyle.

Sect. XIV. *The Glands.*

We shall pass over the Disposition and Structure of the Glands, it being still subject to too many Differences and Disputes in the chiefest Matters, but which perhaps may furnish Posterity with new Matter to convince the Unbelievers, of the Wisdom of their Creator; however it appears in the mean time plain enough, that they cannot attribute it to *meer Chance*, or *ignorant Causes*, that the said Glands are useful to so many, if not to all the Separations of Juices; and that this wonderful and as yet unknown Effect, is produced in their Bodies, *viz.* that the Blood (which in itself is in a manner insipid) being brought into the Glands by its Vessels, the Humours that are separated from it in those Glands, are thereupon impregnated with so many different Tasts and Properties. Thus, that which is separated in the Kidneys is Salt, as are likewise the *Tears* and the *Sweat*, which proceed from the Glands of the Eyes, or comes out of the Pores of the Skill; from the Liver there issues a bitter Gall; from the Glands of the Breasts of Females, a sweet Milk; from the *Glandulæ Salivales*, Spittle, *&c.*

Now every body knows, that upon the Obstruction or Cessation of any of these Humours, grievous Sicknesses and Death itself does sometimes follow, and that almost all of 'em, how different soever their Nature be, are absolutely necessary to Health or Life. The Nerves likewise, and the Arteries, which carry the Blood and the Nervous Juices thereto, or discharge themselves therein; the Veins and Lymphatick Vessels which bring back the Blood and *Lymph*, or what is separated from thence, and which contribute to a Passage or Way for the separated Juices, where they can be useful in so many particular Vessels already discovered; I say, all these things do abundantly instruct us, that each of 'em are formed for a particular End, and are therefore placed exactly where they can be most serviceable; the rather, since Anatomists have discovered (See *Vieussens* in 8*vo*, p. 238.) that altho' there is little

Motion

Motion or Senſation in them, yet, in reſpect of their Bigneſs, more Nerves are found in them, than in any other part of the Body.

Sect. XV. *The Membranes.*

Much might be here ſaid about the Membranes, and which would powerfully ſupport our Deſign, eſpecially if we ſhould here propoſe all the modern Diſcoveries that ſeem to be only in their *Embryo*, and have not yet attained their full Perfection; this is certain, that they have the following Uſes:

1. That they ſerve to cloath or cover ſome Parts, as may be obſerved of the *Pleura* in the Breaſt, and of the *Peritonæum* in the Belly.

2. To form Tubes and Veſſels, as in the Blood, and Lymphatick Veſſels and Inteſtines.

3. To join or faſten ſome Parts together; thus are the Inteſtines faſtened to each other by the Meſentery, and both together to the Back.

4. To divide Cavities into more Parts; thus the *Mediaſtinum* divides the Breaſt into two Spaces, under which Head we may likewiſe reduce the membranous Valves in the Heart, Veins, Lymphatick Veſſels, *&c.*

5. Not to reckon that they are by many eſteemed to be the true Inſtruments of Feeling, and perhaps of other external Senſes.

6. There is yet a greater Service performed by them, *viz.* That many of 'em conſiſt of muſcular Fibres, which by their Contraction or Squeezing, when they make Tubes or other Cavities, are proper to protrude that which is included in thoſe Membranes; as we ſee it happens in the Stomach, Guts, Bladder, Arteries, and the like.

Sect. XVI. *The* Dura Mater, *or thick Membrane of the Brain.*

Monsieur *Pacchionus* ſhews, that according to *Anatomical* and *Practical Obſervations*, the thick Membrane of the Brain, commonly called the *Dura Mater*, has the ſame Property of protruding the Humour ſeparated in the Brain into the Nerves; and ſince this Membrane does inveſt all the Branches of the Nerves, how many ſoever they be, he thinks it is very probable that by a Contraction of its Fibres (like that of the *Periſtaltic Motion*, which happens in the Inteſtines) the Humour is driven forth into the Nerves; I leave this Matter to farther Enquiry; but if one may here mention that which ſeems very likely concerning it, I ſhould think, that unleſs ſomewhat of that Nature did occaſion the Protruſion of the Nervous Juice, ſuch a Power or Faculty could not be deduced only from the Motion of the Heart; foraſmuch as the Matter of which the *Medulla Spinalis* and the Nerves are compoſed, does not ſeem proper to afford a ſwift and ready Paſſage to ſuch a tough and Tupentine-like Humour, as the famous *Malpighius* deſcribes it to be. Moreover, it ſeems to be a neceſſary Conſequence, that in caſe the Heart were the only, or chief Cauſe of the Protruſion of the Nervous Juice, a Nerve being tied or bound, as is uſual in Arteries and Veins, would ſwell up againſt the Band, which many who have made this Experiment complain

does not happen; but if the Contraction of the *Dura Mater*, which encompasses the Nerves, does, without any visible Assistance from the Heart alone, protrude this Humour, every body must own that this *Peristaltic Motion*, by the Compression of a String or Bandage, would be forced to cease; whereupon, that which we experience would follow, *viz.* that the Nerves would not be able to swell and expand themselves by the protruded Matter against the Bandage.

For a further clearing of this Matter, I could have added some Practical Cases, which, without the Hypothesis of such a Motion in the Nervous Membranes, would seem unintelligible, and yet, being handled upon this Foundation, meet with the desired Success, after having tried several other Means in vain. But this is not a time to speak of these Things here; let every one consider and reflect by himself, whether upon seeing the known and undeniable Uses of the Membranes, he must not acknowledge and be convinced of the Wisdom of his Creator.

Sect. XVII. *The Flexibility of the Membranes.*

To speak something of this Matter: Forasmuch as it was necessary for the Support of Life, that the Blood and Nervous Juice should be carried to all the Parts of the Body, and brought back again, it was no less necessary that Vessels, such as the Arteries, Veins, Nerves, and those belonging to the *Lymph*, should be formed for that Purpose: But since, besides this, the Body was to be moved, and that therefore Inflections and Angles were to be made in its Joints, it seemed requisite that these Tubes ought likewise to be flexible, to the end that (for Instance) the Arteries in the Arm and Hand might serve for a Passage to the Blood, as well when they were bent at the Elbow or Fingers, (at which time so many Angles and Inflections are produced) as when the same Arm or Hand being stretched out, the said Tubes were likewise extended in right Lines.

We shall pass by other Remarks concerning the abovementioned Glands and Membranes, having dwelt long enough already upon 'em; as also all that might have been added farther upon many other Matters, such as the Ligaments or Bands by which the Bones are joined together; of the Fat, Skin, *Cuticula*, and the like; those who have a Mind to examine into what is already discovered thereupon, will find Cause enough to extol the Wisdom and Goodness of the Creator.

CON-

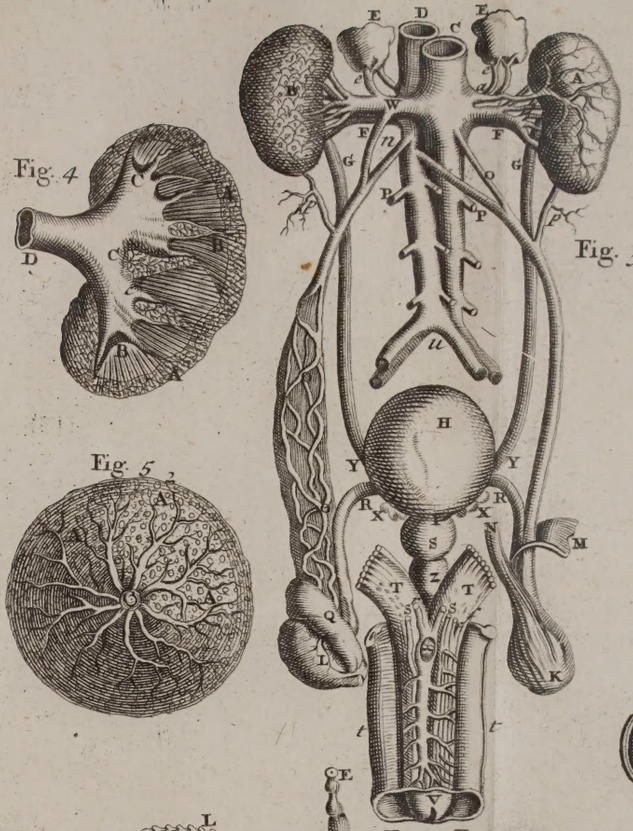


Fig. 3

Fig. 4

Fig. 5

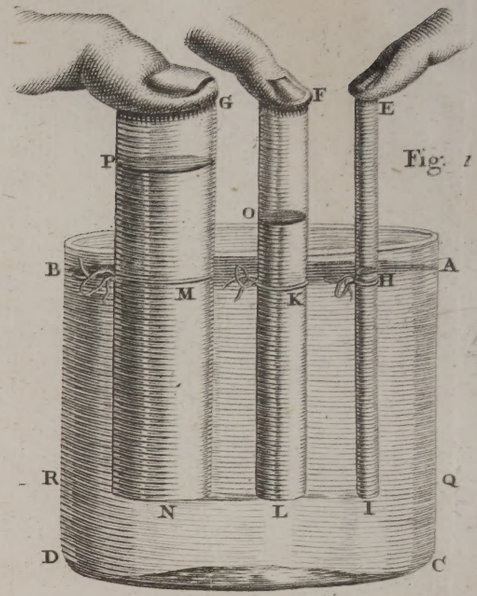


Fig. 1

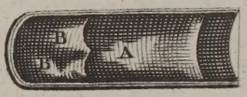


Fig. 2

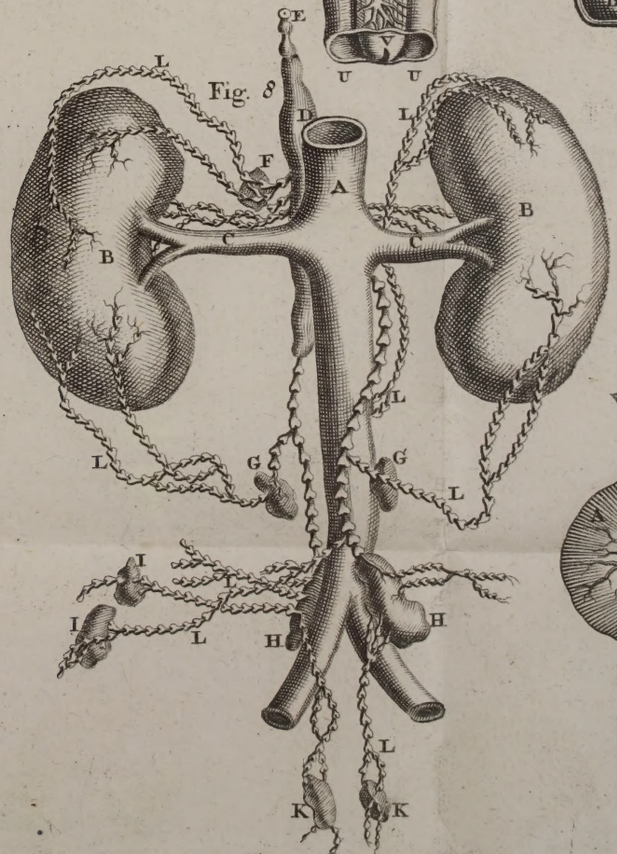


Fig. 8

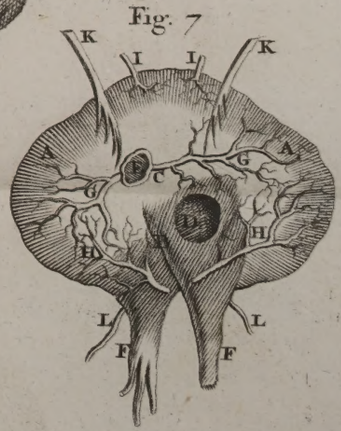


Fig. 7

Fig. 6

CONTEMPLATION X.

Of the Muscles.

SECT. I. *The Transition to the Muscles*

NOW in case that the foregoing should not appear sufficient to convince every Man fully and entirely, of the great Ends of his Creator, and of the most wise Manner of executing the same; (tho' not hardly to be supposed, of such as have thoroughly comprehended what we have already represented to them thereof) yet, at least, this great Truth will appear to be placed beyond the reach of all Doubting, by the single Enquiry only into the wonderful Composition of the Muscles of a Humane Body; which Muscles are, in a manner, the Instruments of all its Motions. And, in case any Body should view, with an understanding Eye, the Insertion or Fastening of the same to the Bones (which are likewise so exactly adapted for the making of Limbs and Joints, whereby Motion may proceed without Interruption) their wonderful Contexture, and the amazing Power and Strength communicated to them, tho' consisting of such exceeding fine and slender Fibres or Threads; I say, whoever contemplates any of these Particulars, must needs acknowledge in all of 'em, the Hand of a Great and Mighty, Wise and Good Creator; the rather, because he has an Example thereof in the greatest Philosophers and Mathematicians, whom the Contemplation of these Wonders, and the Enquiry into the Wisdom that shines out of them, have often compelled to acknowledge the Glory of GOD in these his Works. For one Instance, amongst a great many others, one need only peruse the Dedication of that Book, that Signor *Borelli* published, about the *Motion of Animals*.

SECT. II. *Of the Muscles in General.*

NOW not to ask whether any Body, that understands never so little the Structure of Muscles, could believe, that those which move the Tongue, or the Hands of a Man (to mention no more of 'em) are made without *Design*, without *Wisdom*, and by *Chance* only; and that all the so necessary and useful Functions, performed by them in the Bodies of Men, are produced by ignorant Causes: Can it be imagined, that the Power and Goodness of our Great Creator does so far extend itself towards us, that the Muscles in a Man's Foot have been adapted by him, to serve upon occasion, in the stead of Hands? And yet, as strange as this may seem to be, we have seen, not long

since, a Man, who being born without Arms, could use his Feet almost for all Purposes, and among others, write a fine *Italian* Character with the same, as fast and as accurately, as another good Writer was able to do with his Fingers; to say nothing of many other of his Motions, such as shuffling of Cards, and playing therewith, and managing a good Number of them so dexterously, that he could not have done it better if he had had the use of both his Hands: Now in case those Muscles that move the Feet, had not been of proper Structure for the like Purposes, it would have been impossible that he could have performed all this with his Feet.

Sect. III. *The Description of the Muscles.*

However, to enquire a little more closely into the Structure and Disposition of the Muscles, and to represent the overflowing Wisdom of our adorable Creator, by some few Observations upon the same, let us contemplate *Tab.* V. *Fig.* 1, 2, 3. which will give us a Sketch of the External Structure of some of the Muscles, the great and principal Instruments of all our Motions, and by which alone we exert our Strength.

1. A Muscle then (not to mention here its Artery, Vein, Nerve, and Lymphatick Vessels, which are represented in *Tab.* V. *Fig.* 1. *a b c* tied together) does consist of a Number of fleshy Fibres or Threads B, running parallel mostly, and at equal Distance from each other, and fasten'd at Top and Bottom to a tough Body, called a Tendon, A and C.

Across these fleshy Fibres B, there run others E F, which are likewise Tendonous, Nervous, or Membranous; but as slender as some of 'em are, they are all very tough, and not easy to be broken, and are regularly interwoven with fleshly Fibres.

Now in case the tendon A, the Fibres whereof are here shewn to be a little separated from each other, be fasten'd to a Bone that is unmovable; and the other C, to one that is movable, and can yield to the bending of its Joint; and afterwards each of these muscular Threads B are contracted or render'd shorter by any Force, be it what it will; it is plain, that the Tendon C, will draw the Bone that can follow, and to which it is fasten'd, towards the other Tendon A, and so will bend the Joint that lies between A and C.

The Anatomists are wont to call the Tendon A, which is fasten'd to the immoveable Bone, and towards which the Motion is made, the *Head* of the Muscle; and the other C, fasten'd to the moveable Part, the *Tail*; and the fleshy Threads B, with the transverse ones F E, the *Belly* of the Muscle.

Sect. IV. *The Strength of the Muscles consist in their many Fibres.*

2. It appears from hence, that the more Fibres there are in B, or the Belly of the Muscle, which being contracted do draw, the stronger will be the Action, of such a Muscle, which is also found true by Experience.

Sect.

SECT. V. *Double Muſcles.*

3. NOW to the end that a Muſcle may exert a greater Force, it will be neceſſary, that it ſhould conſiſt of a great Number of Fibres B, which may cauſe it to encreaſe very much in Thickneſs, and ſo fill that Place, in which other Muſcles, ſerving for other Purpoſes, might have been lodged.

Can any Body then, without Amazement, reflect upon the moſt ingenious Manner which it has pleaſed the Wiſe and Gracious Creator to uſe, ſo to diſpoſe many more Fibres in the ſame ſpace, in order to make the Muſcle ſo much the ſtronger, that there ſhall not be requir'd much more Room to place thoſe Fibres? *viz.* by leaving to a kind of Muſcles, that are neceſſary in producing a ſtronger Motion than others, the uſual Breadth or Space, but which they are to fill after ſuch a manner as we ſee in *Tab.* V. *Fig.* 2. in which A B C is the Head of the Muſcle or Tendon, faſten'd immoveably at A, and repreſented in this Figure as cut off; E D is the Tail of the other Tendon, that draws the Joint to itſelf; and between both of 'em are two artful Rows of Fibres F and G, being faſten'd to ihe Head A B C, and running obliquely to the Tail E D, in which they are inſerted; from whence it appears, that theſe two Rows of muſcular Fibres, F and G, being forcibly contracted, the Tendon E D, and the Bone faſten'd to it, which is moveable, muſt be drawn towards A, with this Advantage over that which was ſhewn before, in *Tab.* V. *Fig.* 1. that here (*Tab.* V. *Fig* 2.) many more Fibres, as F and G, can be put in Action in the ſame Space, whilſt they run after this manner obliquely, and as it were acroſs, than when they were extended, as in the former *Fig.* 1. directly only, and at equal Diſtances from each other.

SECT. VI. *Muſcles yet more doubled.*

WE may obſerve again, in *Tab.* V. *Fig.* 3. that theſe Muſcular Threads are, after a wonderful manner, upon ſome Occaſions, much more doubled: A is the Head, and B the Tail of the Muſcle, the which laſt B, by two Tendonous Branches that are extended towards A, and gives an opportunity for the ranging a much greater Number of fleſhy Fibres in ſuch an exact Order; ſo that the Fibres C and D, being faſten'd to G A H, or the Head of the Muſcle, which is ſuppoſed immoveable, when they are contracted in their Length by any Force, each of them draw their Branch F, and theſe two Branches F and F, draw the Tendon B, and whatever is faſten'd thereto, and is moveable, towards A; which, if it were to be performed by Fibres running directly or ſtreight from A to B, as in *Tab.* V. *Fig.* 1. would, by the great Number of them, compoſe a Muſcle almoſt as thick as this Muſcle (*Tab.* V. *Fig.* 3) is long: If what we have here ſaid; does not ſet this Matter in ſo clear a Light as to make it fully underſtood, the Reader may conſult *the Demonſtration of the Force of the Muſcles* SECT. XVII.

SECT. VII. *The Muſcles of the Fingers.*

4. FOR farther Conviction, let us make one only Remark upon ſome of the Muſcles that bend the Fingers; we will therefore conſider the Muſcle

A B (*Tab.* V. *Fig.* 4) as it is fasten'd with its Head or upper Tendon near the Elbow K, and whose moving Threads or fleshy Fibres extending themselves from B to A, do compose the lower Tendon C, and this consisting of four Parts, transmits a Branch to each of the remotest Joints of the Fingers, wherein it is inserted at D; now when the fleshy Fibres A B, are contracted, the Muscles being immoveable at K, it is easie to observe, that the third Joints of the Fingers D D D D, are thereby drawn towards B, and all the Fingers inflected; the rather, if you suppose farther, that the Muscle G F (which is represented here out of its Place, and lying above upon A B) is likewise contracted in its Fibres F G, and by its four Tendons G E, draws over forwards the second Joint of the four Fingers.

Now let every one ask himself, whether he can suppose that it is by meer Chance, *First*, that these Muscles A B, and G F, which bend the extreamest Joints of the Fingers, are placed so far abov the Hand, and even as high as the Arm, and yet extend themselves by their long Tendons C D and G E to those Joints which they are to move, since, if they had lain in the Hand itself, they would have render'd it very unfit for an accurate easy Handling of things? Forasmuch as these Muscles being obliged to exert a great Force, do require many fleshy Fibres, which, when they were contracted and put into Action, would cause the Hand to swell to a great Thickness.

For, that these and other Muscles, such as those described by A B, do upon their Contraction require a greater Thickness, may appear to every one that upon closing with some Force one of his Hands, and turning it into a Fist, does with the other Hand span his Arm below the Elbow; in doing which we will remarkably feel the Muscles that lie there to be swelled: Which thickness, if it were continually produced by such great Muscles lying in the Hand, it is plain, would, upon many occasions, embarrass it in the Exercise of its Functions.

Secondly, Whether he must not acknowledge, that it is a Contrivance beyond the Power of an *ignorant Cause*, that the Tendons G E, of the Muscle F G, do make a kind of a Door or Opening at E? by which Means the Tendons C D of the Muscle A B, pass like a Thread thro' the Eye of a Needle, in order to hinder these last in the numerous Motions which the Fingers make upon many Occasions from being disorder'd by Dislocation or other Accidents; or at least, that the Motions of all the Tendons, lying near or upon each other, may not be so loose and uncertain.

Thirdly, Because there would be danger upon the Contraction of the Muscle A B, that the Tendons C D, which go to all the Joints of the Fingers should recede from the same, when they were bent upwards, and occasion several Inconveniencies, by stretching the Skin too much: Can any one see, that each of these Tendons is encompassed with a kind of a membranous and very strong Sheath, which, without obstructing their Motion at all, makes it remain fast to the Bones of the Fingers; not to mention the great Band just above the Hand, which encircles the Arm in that Place like a Ring, and at once binds together all the Tendons of those Muscles

that

that go to the utmost Parts of the Fingers, preventing them upon great Inflections from receding too far from their proper Places; I say, can any one see all this, without acknowledging the Designs of a Great Creator?

Sect. VIII. *Of the Joints.*

The Joints of a Man necessary to produce the Motions between the two Bones C D E, and A B, (*Tab.* V. *Fig.* 5.) are most commonly of the following Structure; in the first, C G E, there is found a large or smaller Cavity C D E, in which the protuberant Part, C D E F, or I of the other Bone is fasten'd after such a manner, that they can both turn and move in each other: Now in case this protuberant Part, C D E F A, being Spherical, or round, is exactly adapted to the Cavity C D E, it is easy to see, that the Bone B A may be moved at Pleasure upwards or downwards, and on either side; but in case the said Part, I, were not perfectly a part of a Sphere, but round and flat, like a piece of a Wheel, and then inserted into its Cavity, it is plain, that the Bone B A might be moved upwards and downwards, but not sideways.

A Motion analogous to the former, may be observed in the Shoulders and Hip; and to the latter in the Elbow and Knee, some little Circumstances excepted, which, in the main, do not alter the Case, but serve for other Improvements.

Now can the best Mechanist in the World compose or put together any Joints after another manner, whereby so great a Force may be produced, with so much Conveniency, and so little danger of being disorder'd by common Motions? Yea, we know that if one Bone turned upon the other with a sharp Point, in using any Force or Violence, it might presently miss its Support or *Fulcrum* in many Accidents, and the Point run the risk of being Broken, or at least disjointed: It would likewise have been impossible, after the same manner, for a Bone of any common Thickness, to make so acute an Angle as the Elbow does with the Bone of the Arm; nor could the two Bones be in such a Position, with respect to each other, and parallel with the Length of a Man, as the whole Arm is, when extended downwards on the side of the Body, or upwards on the side of the Head. In other Forms or Modes of Joints, besides those which appear in Animals, other Inconveniencies will result from them.

To prevent all which, what safer Method can be made use of to produce the Motion of two Bones, than that which is represented in *Tab.* V. *Fig.* 5. nor by the extreme Point thereof, which might easily be broken or dislocated; but by a Centre I, which you must suppose to be in the middle of the spherical Protuberance, C D E F A, of the Bone A B, or if it be cylindrical about the Line which runs length-wise thro' the Centre thereof, and of which I is the extream Point, as we see it happens in our Joints.

Sect. IX. *The Insertion of the Tendons.*

Suppose A B, and F G, in *Tab.* V. *Fig.* 6. to be two Bones joyned together, which make a Joint at A F; now if one would bend the Bone A B,

A B, at H, and for that purpose, only make use of the Draught and Contraction of the Muscle D R E, which is immoveably fasten'd to D in the same manner as one moves the lowest Bone of the Arm, by bending it in the Joint of the Elbow towards the uppermost Bone or *Os Humeri:* Let us suppose first, that the Tendon of this Muscle is inserted at E, or close to the Hand in the extreme Part of the Bone A B, we may then easily bend these two Bones upon contracting the Muscle D E, at the Joint A F: But if the Bone A B, be brought to A H, in such case the Muscle D E must be contracted or shorten'd to M D; but if one proceed farther, in order to cause the Part H to approach yet nearer to D, by the same Muscle, the whole Muscle D E, which is now shorten'd to D M, will in a manner lose its Length, and be rolled up in a Ball or globular Figure at the Shoulder D; Besides, that when the Bone A B is raised up to A H, the Skin must have so much Space or Room as to cover the whole Triangle, A H D, unless the Muscle were naked and loose from the Arm, as is represented in this Figure.

Now if this should happen in many Parts of the Body, and that more room should be taken up in the Skin, by other Muscles that are larger, and planted in the Bone after the same manner; and so make larger Balls or spherical Figures in the Places where, by their Contraction, they are rolled up together, the Body would lose its Figure at every Motion by such Expansion of the Skin, and upon the ceasing thereof and Extension of the Muscles lengthwise again, the Consequence would be, that the expanded Skin would hang upon the Body like a Bag full of Pleats or Wrinkles, to the end that it might have room enough in its subsequent Motions.

'Tis true, that it seems as if this manner of Insertion might have been passed by, to preserve the beautiful and noble Structure of a humane Body, and a Band or Ligament placed at R, to obviate the receding of the Muscle from the Bone: So that the Body of the Muscle itself being then extended no farther than to D R, a long Tendon E R, need only be stretched to E, and likewise fasten'd to the Joint at its Inflection by the Ligament R, as is shewn to happen in *Tab.* V. *Fig.* 4. where there was a particular occasion for it, namely, that the Hand might not be burdened with too much Flesh.

But in such a case, it cannot also be denied, that if all the Tendons were fasten'd to the extreme Part E, of the Bone A B (*Tab.* V. *Fig.* 6.) notwithstanding that they were kept down by the Ligament R, yet, by reason of their Length, they would fill a much greater Part of the Body, and take up more room than they now do, which would not only be unnecessary, but would likewise displace some other Part.

Not to mention that in this Structure the Tendon R E, running either parallel with both the Bones, G F and A B, or making a very small and acute Angle at E, with the Bone A B as long as the Angle remains so small, could not be able to exert much Force in order to raise the Bone, tho' drawn with great Violence. That it falls out so, in oblique Draughts, the Mechanists know very well; and the same will easily appear by an Experiment in *Tab.* V. *Fig.* 7. if at the end of the Leaver B C, which can turn about an Axis in C, a Force A draws in the oblique Line B A, it will not heave up so easily the same

ſame Beam, to which a Weight D is hanging, as when this Force draws by a leſs Obliquity (in the Line B E,) the Beam and Weight upwards. Wherefore the Muſcle (*Tab.* V. *Fig.* 6.) working in the Angle D M C, on the Bone in H, will perhaps, with the ſame Force, do Eight or Ten times more than at the beginning with the Angle D E C.

With how much more Advantage then has the Great Creator of Mankind been pleaſed to direct this Inſertion of the Tendons in the Bones, after ſo wiſe a Manner, that not only all theſe Inconveniencies are thereby prevented, but likewiſe the Spaces, which would be otherwiſe filled by the exceſſive Lengths of ſo greatly extended Tendons, may with much Eaſe be employed in receiving other Parts that ſerve for farther Purpoſes?

For this End it has pleaſed him in his Wiſdom to place little Eminences at the extream Parts of the Bones, thereby to render them thicker and ſtronger in that Part, and to inſert the Tendons near or in the ſaid Eminences, or cloſe to the Joints in the following Manner:

Let A B and F G (*Tab.* V. *Fig.* 8.) be two Bones, making together a Joint at A F G, which is moveable at the Point C, ſo that both of 'em at their Extremities I K A F are globular, and thicker than their Tubes: Now the Muſcle D E K I is inſerted at I, cloſe to the biggeſt Protuberance of the Bone B A; ſo that it turns about the Eminency K I, like a Rope in a Pulley, if we may be allowed to give ſuch a coarſe Idea of it.

Sect. X. *This Inſertion of the Tendons prevents all Inconveniencies.*

We need not then take much Pains to ſhew, that by ſuch a Method all the aforementioned Inconveniencies are removed; foraſmuch as, *Firſt*, the Tendon being inſerted at C (*Tab.* V. *Fig.* 6.) and not at E, when contracted towards D, cannot make ſuch a Triangle as M C D, and conſequently don't ſtand in need of ſo much Room in the Skin for its Motion. *Secondly*, the Muſcle D E K I (*Tab.* V. *Fig.* 8.) being inſerted in or near the Thickneſs of the Bone, in order to produce a great Velocity at B, the extreme Part of the Bone A B, ſuch as from B to M; it needs only inflect the Point I, in a very ſhort Segment of a Circle to K; for which Reaſon likewiſe the Muſcle requires very ſmall Contraction; nor is it requiſite that the whole Length ſhould be rolled up in a Globular Figure; and thus, the Muſcle being grown but very little thicker by ſo ſmall a Contraction, the Body loſes nothing of its Figure and Beauty; whereas otherwiſe, if the Tendon were inſerted in the extreme Part of the Bone (as at E, *Tab.* V. *Fig.* 6.) the ſaid Body, ſuppoſing the ſame ſhould happen in all its Parts, would for both theſe Reaſons become very monſtrous. *Thirdly*, We may likewiſe ſee here, that the whole Length (*Tab.* V. *Fig.* 8.) remains free from I to B, without being filled by the Tendon of this Muſcle D E K I, and ſo there is a Place left for other Parts and other Uſes. *Fourthly*, The Mathematicians know, that when the Muſcle at K, fix'd to the Knob or Protuberance of the Bone F A I K, performs its Function after the manner of a Pulley, the Line K C, which extends itſelf from the Centre C to K, on account of the Roundneſs of the ſaid Knob, is always nearly of an equal Length; and therefore when the Muſcle

is contracted with equal Force, it always exerts the same Strength when it proceeds to lift up the Bone AB; in which, it has been already shewn, at *Tab.* V, VI, VII, there would have been a great Inequality on account of the changing the Obliquity of the Angles, had it not been for this manner of Insertion.

SECT. XI. *A Muscle exerts a greater Force against a smaller Weight.*

IT is true, that the Muscle DK (*Tab.* V. *Fig.* 8.) acting with a shorter Purchase or nearer the Center, as by the Distance CK, and the Weight against it with a longer CB, the Power of the Muscle must be so much greater than that of the Weight; and that it seems to contradict the Custom of Men, in making Instruments to raise up a greater with a smaller Force, since all their late Discoveries in Mechanics in the several Engines for Motion, such as Balances, Leavers, Pullies, Wheels, inclin'd Planes, and Screws, *&c.* seem to have a contrary View, that is to say, by a smaller Power to move a greater Weight, which Weight they therefore hang upon the shortest Arm.

But no body will be able to deny, *First*, That in the Motion of the Muscles, all the Inconveniencies already enumerated, are avoided by this Disposition, which requires a greater Force in the Muscles.

Secondly, That in the common Mechanical Instruments, where a greater Weight is raised by a smaller Power or Force, the Motion of the Weight is always much slower than that of the Power; and that if it be required to raise the same Weight with greater Velocity or Quickness the readiest Way, the Power must be applied to the shorter Arm, and the same proportionably increased in Greatness only, without being obliged scarcely to augment the Velocity thereof in this Case, which would otherwise be necessary.

SECT. XII. *The Reason why a greater Force is made use of by the Muscles against a smaller Weight.*

IF this Matter does not appear yet clear enough to every one, let them imagine that the Muscle DKI (*Tab.* V. *Fig.* 8.) does by its Force move the Protuberance of the Bone KIAF from V to K, by which means the Point B is at the same time raised to M, and therefore acquires so much more Velocity than the Point V or I, upon which the Force of the Muscle operates, as the Arc BM, or the Arm BC, is so many times longer than the Arc KV, or the Arm KC; and therefore the Muscle itself will be but a very little contracted, as it is plain to every one that considers this Matter.

SECT. XIII. *Convictions from the foregoing Observations.*

NOW can any body, that judges impartially, forbear observing here, that the great Force of the Muscles which is required in exerting their Motions in the abovementioned manner, is so far from being a Diminution of the Wisdom of the Creator, that, on the contrary, it ought to be an Occasion of Thankfulness to every reasonable Person, forasmuch as their gracious Creator has been pleased, in augmenting the Force of the Muscles, to cause them to operate in so easy and almost insensible a Manner, with such little Contracti-

ons,

ons, and yet at the same time to make them produce the Motions of the Limbs upon which they act, with such an unequally greater Swiftness?

Sect. XIV. *The very great Strength of the Muscles.*

Ask an Atheist, ask a Sceptick, ask a great Mathematician and Philosopher, ask all Men without Distinction, and let them say if they can declare after what manner, in such tender Threads of Muscles, as are those of which the Flesh of Men and Beasts is made up, a Faculty is lodged, by which, upon their contracting themselves, such a surprising Force can be produced, as is exerted by them in their Motions.

And let no body think that we are speaking hyperbolically to magnifie the Matter, or to excite their Astonishment: For,

First, Can any one believe, if it had not been demonstrated by that great Mathematician *Borelli*, *Prop.* 87, 88, and 127. that when a Man lifts up with his Mouth a Weight of near two hundred Pounds with a Rope fastened to the Teeth of the lower Jaw (which, according to him, has been done even as far as to three hundred Pound Weight) that the Muscles, named the *Temporalis* and the *Masseter*, with which People chew, and which perform this Work, do exert a Force of above 15000 Pounds Weight?

Secondly, Can any one see without Astonishment, that when the Weight R (*Tab.* V. *Fig.* 9.) of fifty-five Pounds is held up in *Equilibrio* by the Elbow B, of the Arm A B, the Muscle, named *Deltoides*, D C, which only raises the Arm in this Position, exerts a Force of above 60000 Pounds? See the said *Borelli*, *Prop.* 124. at the End.

Thirdly, If any one hanging his Arm directly downwards, lifts a Weight of twenty Pounds, with the third or last Joint of his Thumb; can he learn without Amazement, that the Muscle which bends the Thumb, and bears that Weight, uses a Force of about 3000 Pounds? He that doubts of it, may consult the abovementioned *Borelli*, *Prop.* 86, 126.

But, *Fourthly*, He who sees that the *Musculi Glutæi*, which together compose the greatest Part of the Buttock, and move the same about the top of the Hip-bone backwards, do exert a Force of above 300000 Pounds, when they raise a Weight of 65 Pounds, by extending horizontally the Bones of the Leg and Thigh, according to the Experiment of *Borelli*, *Prop.* 125. I say once again, whoever sees and understands this, must needs admire the Power of his Great Creator, that has endowed our Muscles with so vast a Strength. See *Borelli*, *Prop.* 125.

Especially, if we here add, *Fifthly*, that calculating all the Forces of the Muscles, that are exerted when a Man, standing upon his Feet, does only leap or spring upwards the Height of about two Foot; if the Weight of such a Man be a Hundred and Fifty Pound, the Muscles in that Action will exert above 2000 times more Force, that is to say, about 300000 Pounds. *Borelli*, *Prop.* 175. computes it yet higher.

And, *Sixthly*, that the Heart at each Pulse or Contraction by which it protrudes the Blood out of the Arteries into the Veins, exerts a Force of above 100000 Pounds; see the same *Borelli*, *Prop.* 76. *Part.* 2. we chuse rather to

ſpeak of theſe Matters in round Numbers, than exactly to follow his Calculations, (which are every where larger) that we may prevent any Cavelling in theſe ſurpriſing and wonderful Matters.

Sect. XV. *Convictions from the foregoing Obſervations.*

Yea, if the Force of the Muſcles were really much ſmaller, ought we not to ſtand amaz'd at it, whilſt we thus diſcover in our Bodies the Divine Power of our Creator, producing ſuch ſtrange Effects with a Matter ſo fine and tender as the Fleſh of an Animal, contriving and diſpoſing them in ſo narrow a Compaſs, and adapting 'em to ſuch regular Ends? When we ſee the Joints form'd, and their Motions maintain'd by perpetual Fountains of Oyl and Water (of which more hereafter) to preſerve them ſmooth and ſupple? And above all, when we ſee ſuch ſurprizing Force in many Muſcles ſo readily obeying his Will, that is to ſay, Moving and Reſting as we pleaſe; and others again, moving Spontaneouſly and Involuntarily; and farther, a Faculty or Power placed in the Muſcles themſelves, whereby, tho' their Motion ceaſes, they are contracted or ſhorten'd; and this Power balanced by a contrary or oppoſite one, in ſuch a manner, that the Parts of the Body may alſo keep their juſt Proportions, without any Concurrence on our ſide; as, for Inſtance, the Mouth is preſerv'd and held exactly in the middle of the Face, by two Muſcles drawing againſt, and balancing each other: this is very obvious, when one of thoſe Muſcles having loſt its Force by any Diſeaſe, the other ſhall convulſe or draw the Mouth awry, and thereby the Face will be depriv'd of its beautiful Regularity and Uniformity.

Sect. XVI. *Tranſition to the Demonſtration of the Force of the Muſcles.*

Whilst I am writing this, it is objected to me by a certain Learned Perſon, that what has been ſaid about the Force of the Muſcles, will not appear to all Readers ſo ſtrange as really incredible; ſince it will not eaſily be admitted by any Body without further Proof, that a Power of ſo many Thouſand, yea, Hundreds of Thouſand Pounds, can be exerted by the Fleſh of a Humane Body: Wherefore, that we may not give occaſion to *Atheiſts* and *Scepticks* to think that we rather affect to ſay ſomething here that is ſurprizing and uncommon, than what is true, it ſeem'd neceſſary to ſhew in ſome manner the Grounds of our Aſſertions: He own'd indeed, that I had referr'd thoſe who doubted, to *Borelli* and his Learned Work, but that the ſame could not well be read and underſtood but by experienced Mathematicians; but foraſmuch as all of them did not entirely agree in their Inveſtigations of Nature, the unhappy Philoſophers, whom we endeavour to confute, might pretend from thence to avoid the Force of this plain Proof of a Great, Powerful, Wiſe and Gracious God.

For which reaſon, he added, if it could conveniently be brought about, it would be of great Uſe to demonſtrate this Force of the Muſcles, which ſo far ſurpaſſes all Belief, upon ſuch Grounds as might eaſily be apprehended by a ſenſible Reader, tho' not well vers'd in Mathematical Sciences.

This

Fig. 1

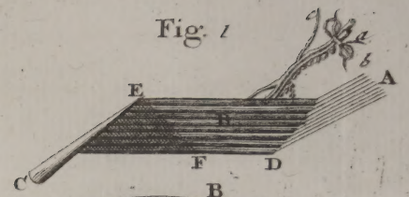


Fig. 2

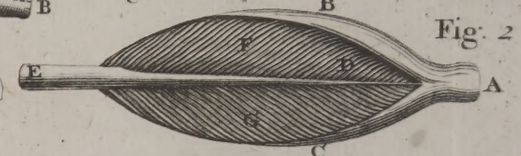


Fig. 3

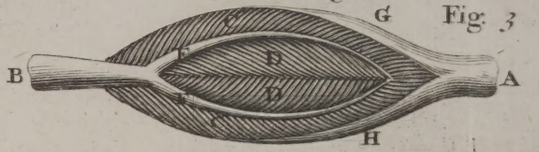


Fig. 4

Fig. 5

Fig. 6

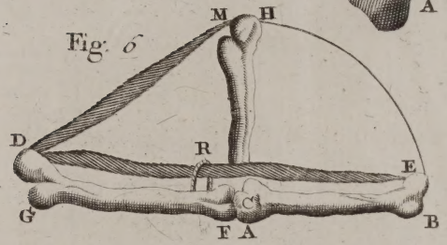


Fig. 7

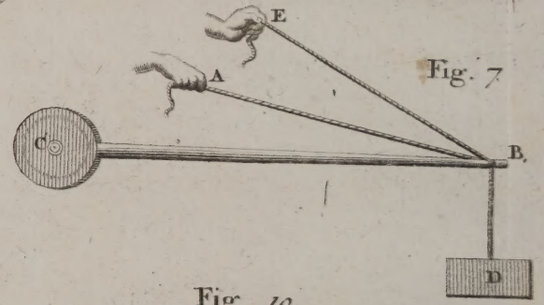


Fig. 8

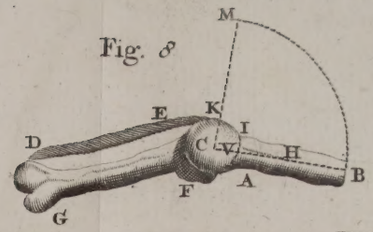


Fig. 9

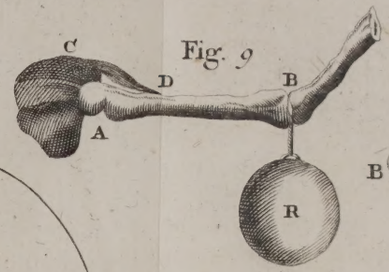
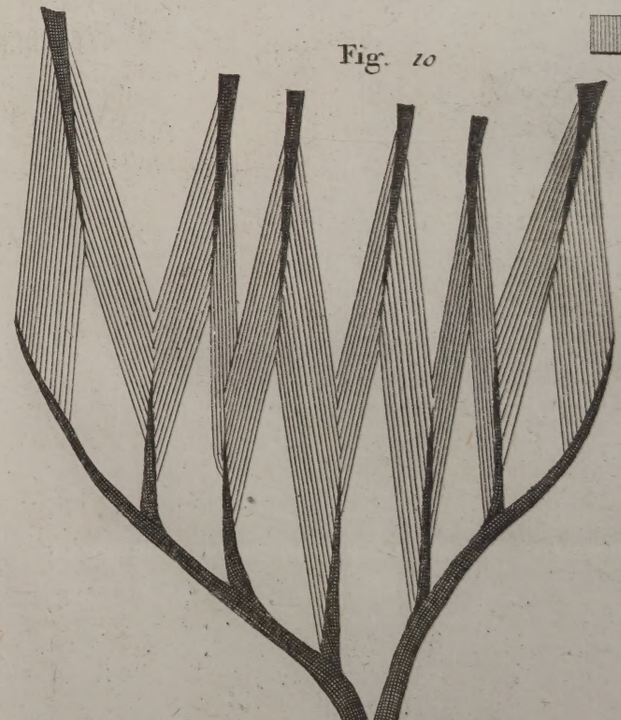
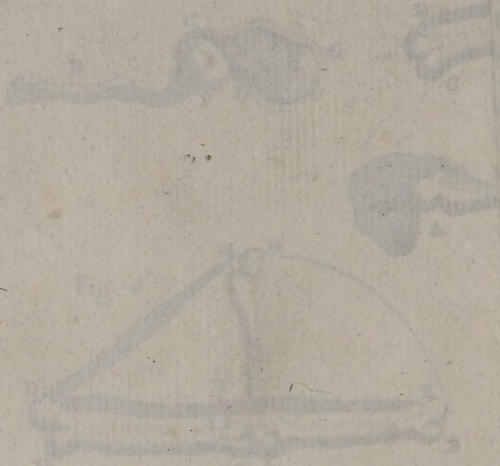


Fig. 10





This Consideration has prevail'd on me to insert here the following short Digression, which may help to give those that are unexperienced, a clearer Conception of what *Borelli* has discover'd in this Matter, in which I have therefore represented the Greatness of the Force of the Muscles as clear as I can, without adding those Mathematical Demonstrations, so tedious to some, and so unintelligible to others; requiring nothing more of our Reader, but that, besides the knowledge of a few and common Mechanical Instruments, he understands never so little the Use of the Tables of *Sines*, and the Computation of plane Rectangular Triangles, which may be learn'd by any reasonable Person, if he be rightly instructed, in a Week or less; in case he thinks this great and convincing Proof, of the Perfections of his Creator, deserves such Pains: However, if there be any who have no Inclination this way, they may pass by these Demonstrations, and proceed to the following Matters.

Sect. XVII. *Brief Demonstration of the Force of the Muscles.*

1. Now to represent to an ordinary Capacity, and convey, in some measure, to the meanest Understanding a clear and distinct Notion of the great Force of a Muscle, as it were by Gradations: Let us suppose (*Tab.* VI. *Fig.* 1.) that the Muscle K D Q P, is the *Deltoides*; of which mention has been made above (*Sect.* 14.) whose Office is to lift up the Elbow.

2. This, according to *Borelli*, *Prop.* 82. is a Radius Muscle, composed of several Plumiformar Muscles, like H Z Q L, and G V P W. See below 154.

3. Let us here, for Plainness and Conveniency sake, imagine this Muscle to consist only of these two Plumiformar Muscles, *viz.* H Z Q L, and G V P W.

4. How this Force will be calculated, when the Muscle is composed of more Plumiformar Muscles than two, will be made appear hereafter.

5. These Muscles are called Plumiformar; because that in G V P W, the moveable Tendon, D G P has inserted into it, on both Sides, a great number of carnous Fibres, as G V, G W, all which, like the single Feathers of a Quill, run parallel to each other, and are fasten'd to the opposite Tendon V P W, which being immoveable, cannot follow.

6. Seeing, therefore, these carnous Fibres, G V and G W, are both of them fast and immoveable at V W; and seeing, that each of them is to be contracted by a Power, be it what it will; the Consequence must be, that of necessity they are to be drawn upwards, together, from G to N.

7. After the same manner, likewise, the Point H is drawn up to O, in the other Plumiformar Muscle H Z Q L, by the Contraction of all the lateral Fibres, as H Z and H L.

8. We see, that the Points H, G, or rather the Tendons, D H and D G, being lifted up to O and N, the Point D, and therewith the Tendon K D, must necessarily follow directly, and be drawn up, in a Right Line, to X.

9. If the Forces, which draw the Points H and G upwards to Q and P, be equal, the Obliquities or Angles, H D X and G D X, muſt certainly be equal alſo; then taking this for granted, as we ſuppoſe it is, it follows, that there will be an Equality in the Muſcular Fibres, aforementioned, not only as to their Obliquities or Angles, N G M, N G R and O H L; O H Z, which theſe, and all the other Fibres form with their moveable Tendons, H Q and G P; but there will alſo be an Equality as to their Forces.

10. Theſe Angles, H D X and G D X, as alſo, V G N and W G N, and in the other Muſcle, Z H O and L H O (which form the Directions of the obliquely drawing Forces D G or D H, with the Direction of the perpendicularly drawing Force D X; and of the Muſcular Fibres, G V, G W, or H Z, H L with their moveable Tendons) we ſhall hereafter, for Brevity ſake, call *Angles of Obliquity*.

11. To proceed; let B be the Elbow upon which the Weight T hangs; let B I A be the upper Bone of the Arm or *Humerus*; let K E F A be the round Bone thereof, which can turn in the Cavity E F, in the Shoulder, about the Center C; and laſtly, let the Tendon D K I, which is inſerted in the Bone at I, touch the round Bone at K, at the Extremity of it.

12. Thus it muſt appear to every one, that when the Tendon D K I (8.) is drawn up to X, according to the Line K X, the whole Bone I B A, will turn about the Center C; and K will be moved to *n*, and B to *m*; 'tis plain the Weight T, by the contracting Power of the two Plumiformar Muſcles, muſt thus be lifted up.

13. This therefore is a ſhort Deſcription of the Action of the Muſcle *Deltoides*, when it lifts up the Weight T hanging upon the Elbow B; or rather Poiſing it in Equilibrio.

14. To enquire further into the Force of this Muſcle, let us begin from the Weight T, and proceed upwards to the Muſcle.

15. This Weight T, according to the Obſervation of *Borelli*, (*Prop.* 84.) is found to be 55 Pounds; which (the Weight of the Arm being included) is what being hung at the Elbow may tolerably be ſupported.

16. Since the Weight T draws the Bone of the Arm B A I downwards, and the Tendon I K D, draws the ſame upwards, by the Force of the Muſcle D Q P;

17. It is eaſy to perceive (and is what has been obſerved before) that theſe two Powers here do reſiſt each other, like the *Steelyard*, or Angular Balance, B C K.

18. We likewiſe ſee that the Arms of this Balance B C and K C, are of very unequal Lengths.

19. Now every Body knows that a Weight, ſuch as *t* here, drawing with a Chord *t r* D K, the ſhorteſt *Brachium*, or Arm, C K, muſt be much greater than the Weight T, which hangs at the longeſt Arm C B, to cauſe them to balance one another.

And therefore we ſee, by theſe unequal *Brachia* B C K, that the Force of the Muſcle D Q P, which draws the Arm K C, inſtead of the Weight *t*, muſt be greater than the Gravity of the Weight T, or 55 Pounds.

21. To

21. To proceed then to ſhew how much the Force of this Muſcle muſt be greater than the Weight T: It is a known Rule in *Mechanics*, that if the Weights T and *t*, are faſtened to a Balance of unequal Arms turning at C (which either hang ſtreight down, as in *Tab.* VI. *Fig.* 2; or makes an Angle at C, as in *Tab.* VI. *Fig.* 3.) each of them drawing at right Angles at K and B, the reſpective Arms of the Balance, the Weight *t* hanging at the ſhorteſt Arm K C, muſt be, in order to make an Equilibrium, ſo many times greater than the Weight T at the longeſt Arm; as the longeſt Arm B C, is longer than the ſhorteſt Arm K C.

22. Every one that doubts of this, may from Experience be convinced, by making ſuch Balances or Steelyards, which may be effected, by bringing the Gravity of the Arm itſelf in ſuch a Poſition with the Weight, as mathematically to obſerve an Equilibrium therein.

23. Now, granting the Rule (21.) to be true, as it apparently proves to be; *Borelli* finds (*Prop.* 84.) by exact Scrutiny, that the Length of the Elbow B C (*Tab.* VI. *Fig.* 1.) from B, where the Weight T is ſuſpended to C, the middle of the round Bone or Joint (which Length B C, makes the longeſt Arm of the Balance) is fourteen times as long as K C, the half Thickneſs of the ſaid round Bone K E F A; the Semi-diameter of which makes the ſhorteſt Arm of the Balance.

24. For which reaſon then, according to the foreſaid Rule (21.) the Tendon K D, drawing from the ſhorteſt Arm K C, ought to have fourteen times the Force of the Weight T, in order to reduce the whole to an Equilibrium.

Now this Weight T, according to (15.) the Obſervation of *Borelli*, is 55 Pounds: So then the Force wherewith the Tendon K D muſt be drawn up by the Muſcle, or by the Weight *t*, in order to maintain the ſaid Equilibrium, is equal to 14 times 55, or to 770 Pounds.

25. And thus we ſee how much the Force, which the Muſcle D Q P exerts, muſt over-balance the Weight T, which it raiſes up only from the Head of the Steelyard B C K; becauſe it draws the ſhorteſt Arm K C.

26. For inſtance; imagine the Tendon K D continued to *r*; and further, ſuppoſe the Weight *t*, hanging perpendicularly from the Pulley at *r*, and ſo faſten'd to the Tendon K D, that the Pulley may play (or run round); 'tis manifeſt, that the Weight *t* muſt amount to 770 Pounds, if it Poiſes the Weight T, or makes an Equilibrium with it.

27. But now if this Force of 770 Pounds were to be produced by two other Forces operating obliquely, according to D G and D H (inſtead of the Weight *t*, whoſe Power is directed by the Strait Line K D *r*) we ſhould perceive this Motion to be, according to what the two Plumiformar Muſcles, H Z Q L and G V P W, muſt neceſſarily be apprehended, by their moveable Tendons, D Q and D P, to produce.

28. It is then plain, that each of theſe two Plumiformar Muſcles, H Z Q L and G V P W, muſt raiſe the half of 770, or 385 Pounds; it being granted, that the Forces, as well as the *Angles of Obliquity* H D X and G D X (10) of each Plumiformar Muſcle, are equal to one another.

29. There-

29. There does therefore occur in this Muſcular Structure another Machine, or rather a Pulley, whereby we may learn, that the Plumiformar Muſcles will each of them exert a greater Force than 385 Pounds, or 770 Pounds together; and this Augmentation of their Force is owing to the Alteration of the Line of Direction of the Power which here draws, by theſe two Muſcles, obliquely; deviating, at the ſame time, from the direct Line K D X *r*, and forming the Angles K D G and K D H.

30. To prove this, ſuppoſe (*Tab.* VI. *Fig.* 4.) a Weight K, of 770 Pounds, hanging at a Cord, K D *r*, which turning over a Pulley *r*, has at his other End another equal Weight *t*, *viz.* of 770 Pounds, capable of ſupporting the firſt Weight K.

31. Now let it be imagined, that this Weight *t* is taken quite away; but to ſupply its place, two other Weights are ſubſtituted, *viz.* P and Q; the Chords of which Weights, *viz.* P *n* D and Q *b* D, run about the Pullies *n* and *b*; and both are faſten'd to the Rope X D at D; and form the Angles *n* D X and *b* D X.

32. It is plain, that if the Weights P and Q be equally heavy, and the *Angles of their Obliquity* (10.) G D X and *b* D X, be equal, each of them muſt raiſe the half of the Weight K, which is computed to be 770 Pounds; that is to ſay, each muſt raiſe 385 Pounds.

33. This is what is obſerved before in the Caſe of the two Plumiformar Muſcles, Z Q L and V P W, (28.) with no other Difference than here, inſtead of the two Plumiformar Muſcles, two Weights, P and Q, are ſubſtituted, to render the Demonſtration more intelligible.

34. But here occurs another notable and known Truth in Mechanics: If two equal Weights, P and Q, do hold in Equilibrium a third Weight K, with the Apparatus of Cords repreſented here, in *Tab.* VI. *Fig.* 4. and deſcribed (31.) each of thoſe two Weights, P and Q, muſt be ſo many times heavier than the half of K (or 385 Pounds) as the Line D G is longer than D X.

35. Obſerving at the ſame time, that the *Ratio* (or apparent Length with reſpect to each other) of the Lines D G and D X, are found by taking *ad libitum*, a Point, as X, in the extended Line K D, and from thence drawing the pricked Line X G, ſo as to make the right Angle G X D.

36. To know then how many times the Weights P and Q are each of them greater than the half of K, or 385 Pounds, we need only enquire how many times D G is longer than D X.

37. And this is found by knowing the Chord of the *Angle of Obliquity*, G D X (or the Number of Degrees ſubtended by a Line falling at right Angles at X, and cutting part of the Arc of a Circle at the Points X or G, the Center of which Circle is to be at D): Therefore, having found the Angle G D X, the Angle D G X is known of courſe; becauſe the whole Triangles being rectangular, the two Angles, G D X and D G X, muſt be equal to one Right Angle, or to the Angle D X G.

38. After which (35.) drawing a Line at pleaſure, *d x* (*Tab.* VI. *Fig.* 5.) and ſo as it may be divided into 385 Parts, by a Pair of Compaſſes, and drawing from it at *x* another Line *x m*, which makes the Right Angle *d x m*,

and

and drawing from *d* another Line, *d n*, which must cut *x m* at *g*, and form with *x d* the known Angle of Obliquity *x d g*.

39. Then if we measure the Line *d g*, with the Compasses, and observe how many such Parts (of which 385 make up the Line *d x*, in this instance) are contained in the said Line *d g*, we shall find, in this case, the Parts of *d g* to amount to about 442,4. Whereby it will be known that *d x* in *Fig.* 5. or D X, in *Fig.* 4. : Is to *d g*, or D G : : As 385 : To 442.

And according to the Rule (34.) that the Weight P or Q, will each of them amount to 442 Pounds, and consequently so far exceed the half of K, being 385 Pounds: By this way, even those who do not understand Mathematics, may be made to apprehend these Demonstrations.

41. But they who have made the least Progress in that Science, and are but tolerably versed in the Calculations of Plane Trigonometry, may, without this round-about way of Admeasurement, or making the new Right-angled Triangle *d x g*, (*Tab.* VI. *Fig.* 5.) have recourse to the Tables of *Sines*, *Secants* and *Tangents*, with the same ease as if the Line D X (*Fig.* 4.) were really divided into 10.000,000 of Parts; or, if so much Exactness be not required, into any less Number.

42. For if you search those Tables for the Secant Line of such a number of Degrees as the Oblique Angle G D X contains, you have exactly the constituent Number of Parts of the Line D G.

43. And comparing these 10.000,000 Parts, with the Number found in the Secant corresponding, you will have the Proportion of D X to D G; or know how many times D G exceeds D X in number of Parts; and consequently how much heavier the Weight P is than the half of the Weight K.

Therefore it appears,

44. That as the *Radius*, or 10.000,000 : To the Secant of the *Angle of Obliquity* G D X : : So is D X : To D G; or (*36.*) the half of the Weight K, to the Weight P.

45. Now to bring this home to our Case, *Borelli* finds (*Prop.* 82.) that the Obliquities of the Tendons D G and H D (*Tab.* VI. *Fig.* 1.) upon the Tendon K D X, *viz.* the Angles X D G and X D H, are equal, each, to 30 Degrees; and the Secant of 30 Degrees, as appears by the said Tables, is 11.547,005.

46. Now since an Inconveniency attends the Greatness of these Numbers; and since the Calculation here before us does not seem to require so great Exactness, the Proportions may be sufficiently expressed, tho' as many Letters, or Cyphers, be cut off from each of these Numbers (*viz.* 100.000,00 and 11.5470,05) as shall be thought convenient; that if from each five Figures or Cyphers be laid aside, the remaining Proportion, 100 and 115, will express this Matter clearly enough: Therefore, if D X were to be divided into 100 Parts, D G would as much exceed D X as 115 exceeds 100.

47. Supposing the Case to stand thus: These 100 Parts (or the Radius) according to (34.): Are to 115, or the Secant of 30 Degrees (or D X to G D) : : As 385 Pounds, or the Half of the Perpendicular Weight K : To 442 Pounds, or the oblique suspended Weight P, (*Tab.* VI. *Fig.* 4.)

Which is in brief thus; DX : GD :: $\frac{K}{2}$: P, or the ſame in Numbers; 100 : 115 :: 385 : 442.

48. Now this Weight P, repreſents the Force of the Plumiformar Muſcle, GVPW (*Tab.* VI. *Fig.* 1.) which therefore in this caſe muſt be 442 Pounds.

49. And thus we ſee how the Muſcular Force, which was augmented before (24 and 25) by the ſhortneſs of the Arm of the Steelyard, is here yet more augmented by the Obliquity of this Draught, tending towards DG; namely, from 385 to 442 Pounds.

50. So that in caſe the Tendon DP, were lengthened to *s*, and moved about a Pulley there, a Weight *q*, muſt be ſuſpended to it there; and likewiſe one of the ſame bigneſs muſt draw the Tendon DQ, to the end, that by making together 884 Pounds, they may raiſe directly, or perpendicularly, the Tendon DK, by their Oblique Draught; whoſe Force, according to the Direction DX, is equal, only, to 770 Pounds.

51. But if, farther, we ſhou'd again remove the Weight *q*, as before, and raiſe the Tendon DG, according to the Direction DP, with the ſame Force of 442 Pounds, by the help of the two obliquely acting Powers, according to GV and GW

52. The ſame Machines or Pullies occur here as before (29, *&c.*) (*Tab.* VI. *Fig.* 4.) and the ſame Properties in all Points.

53. And it follows (32 and 33.) that the Powers GV and GW, acting accordingly (*Tab.* VI. *Fig.* 1.) each will raiſe to the half of 442, or 221 Pounds.

54. As alſo, that the Force GW, in order to operate as aforeſaid, muſt be as many times greater than 221 Pounds, or the half of the Weight *q*, as GW is longer than GS; ſuppoſing again (35.) that GSW is a Right Angle.

55. The Proportions of both which, GS and GW, are found, if the *Angle of Obliquity* SGW be, moreover, known; after the ſame manner as we have ſhewn above (from § 35 to § 44.)

56. That is (by the Rule 44.) As the Radius, or 100,000 : Is to the Secant of the *Angle of Obliquity*, SGW (or by 34) : : So is the Half of 242 or 221 Pounds : To the Force that muſt act according to GW.

57. Now, in order to diſcover the Power of this laſt Force, *Borelli* finds (*Prop.* 82.) that the *Angle of Obliquity*, SGW, made by the contracting of the carnous Fibres GW, with their moveable Tendon GP, is an Angle of 8 Degrees; the Secant of which (ſtriking off the two laſt Cyphers) appears by the Tables to be 100,982 : 58.

58. And conſequently, according to § 47,

As 100,000, or the Radius : To the Secant of 8 Degrees, or 100,982 : : So is the Force of 221 Pounds drawing directly : To 223 Pounds; or the Force which draws obliquely, according to GW, when it raiſes the ſaid 221 Pounds perpendicularly, according to the Direction GS.

Which in ſhort ſtands thus;

100000 : 100982 : : 221 : 223.

59. So then the carnous Fibre GW, exerts a Force of 223 Pounds in this Caſe when it operates ſingly; and when the Plumiformar Muſcle GVPW, has no more than this only moveable Fibre GW on this ſide.

60. We

60. We will suppose it to be really so, in order to render it more intelligible to unexperienc'd Persons; and afterwards briefly shew, how it wou'd be, in case there were in each half G P W, of the Plumiformar Muscle, as many more Fibres as may be imagined.

61. In the mean while, since according to this Supposition there are two Plumiformar Muscles, as G V P W and H Z Q L, of which this great Muscle, or *Deltoides*, is composed; and since each Plumiformar Muscle has two Sides, each of which (59.) exerts a separate Force of 223 Pounds, and joyntly a Force of 446 Pounds; this then is the Force of the whole Plumiformar Muscle G V P W.

62. Thus we see that this whole *Deltoides*, consisting of two Plumiformar Muscles, or four half Sides thereof, by the Force of the Steelyard B C K (25.) does balance, by the first oblique Draught of the Muscular Fibres, G V, G W, and H Z, H L, a Force, or Weight, four times 223 Pounds, or 892 Pounds.

So that instead of the Force of each carnous Fibre G W, *&c.* there hung, suspended, a Weight *p*, of 223 Pounds to each; four such Weights must operate with the same Force, as the four sides of the two Plumiformar Muscles; and thereby the Weight T, hanging to the Elbow B, wou'd be kept in Equilibrium.

63. Now to pass on further to a greater Augmentation of the Force of the Muscles, produced by the Structure of the carnous Fibres G V, G W, Z H, H L, *&c.* which are moveable, and also produced by the Texture of the Muscles themselves.

64. We find, after the nicest Scrutiny, that these Muscular Fibres W G (*Tab.* VI. *Fig.* 1.) have several little hollow Interstices; which, whilst the Fibres are extended lengthwise, as A B C D E (*Tab.* VII. *Fig.* 1.) are included within Right Lines; but when the Power which extended these Fibres ceases, these Interstices appear in circular Figures, as *w g*, *&c.* (or G M W, *Tab.* VI. *Fig.* 1.)

65. If now by the Fibre W G being immoveable at G, a Weight T, suspended to it, must be raised; 'tis plain, that in performing such an Action, by any Force (whatever it be) the Breadth or Thickness of the said Fibre must be imagined to be encreased; and the Length, at the same time, must necessarily be diminished.

So that the Parts A B C D E (*Fig.* 1. of *Tab.* VII.) being dilated, or made wider, do assume the Figures *a b c d e*; by which the Length of the Fibres W G, becomes visibly shortened; *viz.* from W G to *w g*; and the Weight T, at the same time, is raised up to *t*.

66. This Tumefaction, or Swelling of the Fibres, which compose the Body of the Muscle, does palpably appear in several Parts of our Bodies; and in several particular Muscles, which contract themselves in the Exercise of their proper Functions.

Let any Man, with either Hand, take hold of his other Arm just below the Elbow, to convince himself, whether or no he does not feel the Muscles

of the Arm ſwelling and contracting themſelves, when he opens and ſhuts the Fingers of the Hand, which he ſqueezes that way below the Elbow.

67. Now whether the Figure of theſe long Particles, or little Tubes A B C D E (*Tab.* VII. *Fig.* 1.) be round, as a b c d e; or whether they may be imagined Square, as *a b c d e*, the better to determine their Co-operation with other Fibres, we ſhall not pretend here to decide; it being a Matter foreign to our preſent Purpoſe.

68. Neither do we here enquire after what manner, or by what Cauſes the Interſtices A B C, *&c.* become thicker, or how they aſſume the Form of *a b c*, *&c.*; concerning which, we leave every Man to enjoy his own Opinion, till the true and certain manner thereof be clearly and inconteſtably demonſtrated.

69. This is certain, that each carnous Fibre, as W G, conſiſts of a multitude of little Inſtruments, as A B C D E, each of which do become thicker and ſhorter in Motion.

70. The truth of the laſt appears experimentally from above *(66.)*; it remains therefore to ſhew theſe little Inſtruments, *a*, *b*, *c*, *d*, *e*, *f*, *&c.* (*Tab.* VII. *Fig.* 2.) in each Thread, *a p*, where a Contraction happens (and conſequently the Breadth muſt be augmented) are very many in Number, and the Minuteneſs of each, exceeding fine.

71. Let us ſuppoſe, in *Tab.* VII. *Fig.* 3. *a e* to be a Fibre with Interſtices; which, in its utmoſt Extenſion, reaches to *e*, or is of the Length *a e*; at the Tendon whereof a Weight *q* being ſuſpended, it is held in an Equilibrium; but as ſoon as *a e* is contracted to *a d*, the Weight *q* is raiſed to P.

72. Imagining this Fibre *a e* to conſiſt but of one Machine, *viz. a b c d*, it wou'd be able to raiſe the Weight *q* up to P; becauſe the Line *a e* wou'd even by this means be contracted to *a d*.

73. But that this will not anſwer the Motion of Muſcular Fibres, which we are here accounting for, appears;

Firſt, Becauſe when the Machine *a e* is ſo long, the Thickneſs *b c*, would be incomparably greater than we now perceive in contracted Muſcles.

74. For if a double Fibre *a e*, were two Inches long, which by Contraction or Swelling, muſt be blown up into the Circular Figure *a b c d*, the ſaid Circle would be 4 Inches, and its Diameter *b c*, above one Inch and a Quarter; as is plain to thoſe who know that the Circumference of a Circle is to the Diameter, As 22 to 7, or thereabouts.

75. We have choſen here to repreſent an extended Fibre rather by a long Line, and a contracted one by a Circle, than by a Tube and a Globe, to which their Reſemblance bears greater Affinity; becauſe we wou'd render the matter as intelligible as may be to all Capacities.

76. *Secondly*, If the whole Fibre conſiſted of one Machine only, as *a b c d*, and one ſhou'd cut it acroſs at *b c*, the whole Fibre would at once be diſabled from contracting, or exerting its drawing Power, ſo that it could never draw itſelf back to *a*, but more eſpecially, if the Contraction be perormed by filling the Machine, or by the Expanſion of any Matter included

 therein;

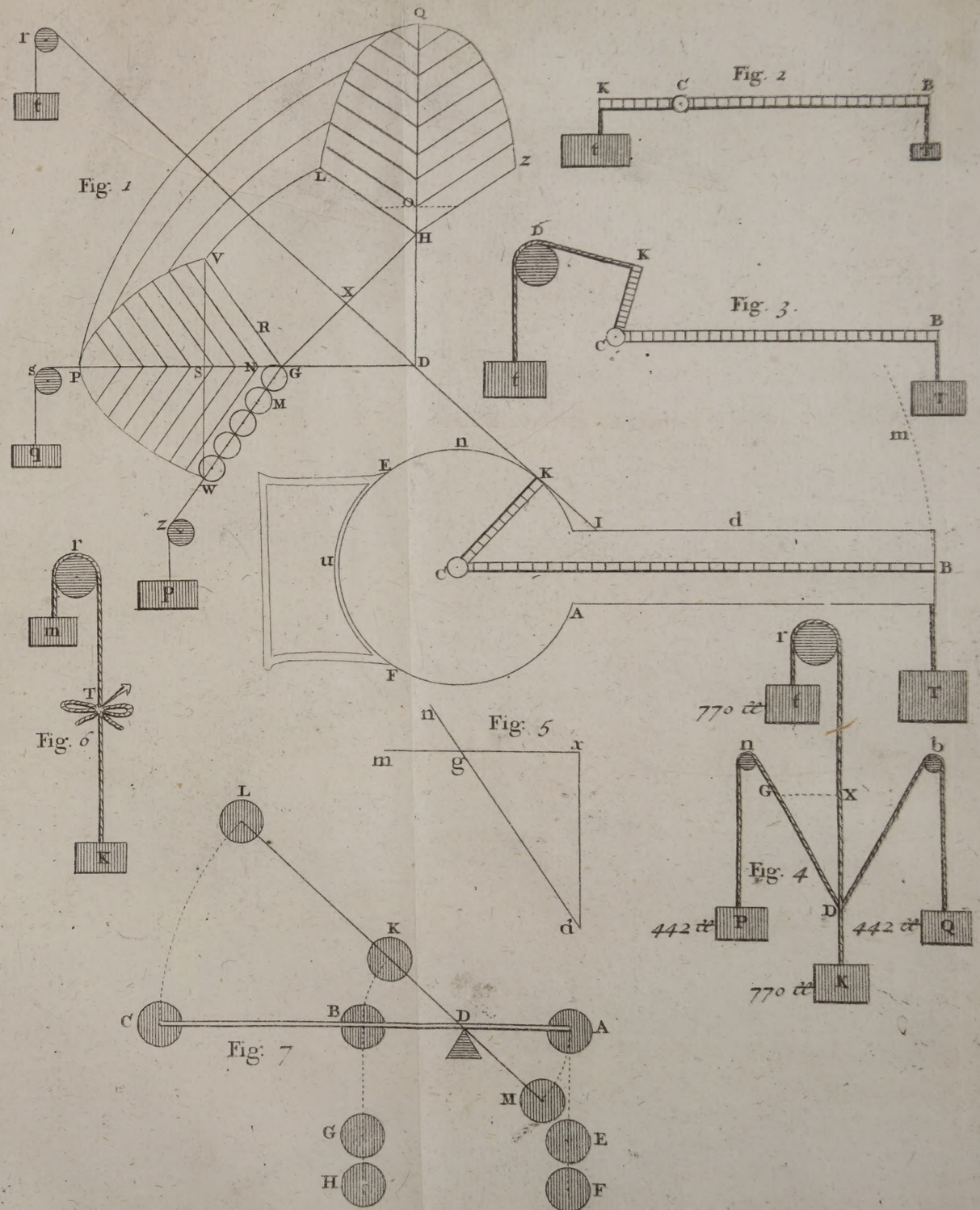
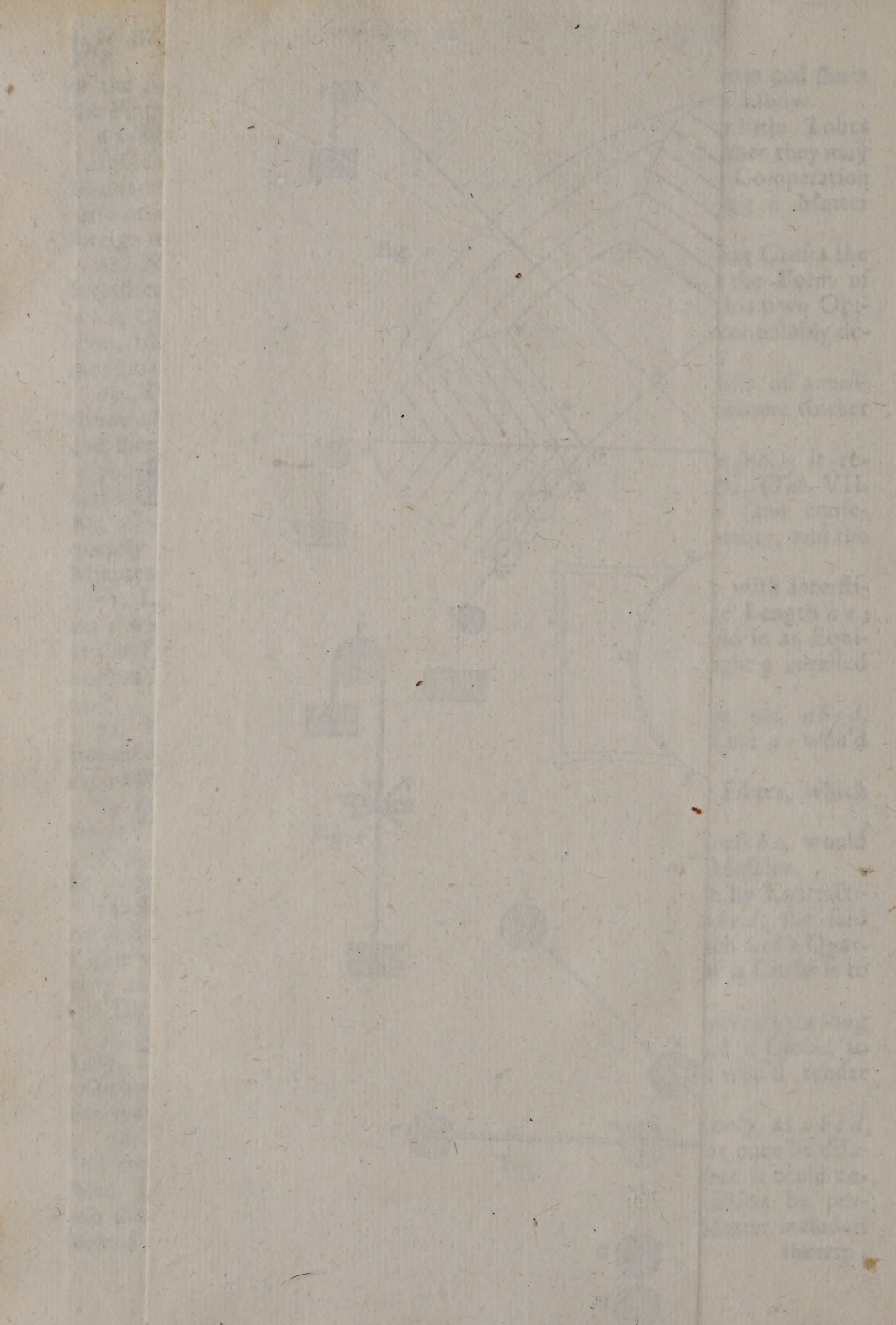


Fig. 1
Fig. 2
Fig. 3
Fig. 4
Fig. 5
Fig. 6
Fig. 7
770 dr
442 dr
442 dr
770 dr



therein; but in a Muſcle cut acroſs, Experience proves a Motion or Contraction, even after its Fibres are cut aſunder.

77. If now the Fibre conſiſted of two Machines, *a k g m* and *g h d i*, and which ſhou'd be be divided from one another at *b c* through *g*, the firſt Machine muſt be contracted to *a*, and the ſecond to *d*.

78. But if this ſhould happen at *k m*, the Part *a k m* being cut through, would not be able to contract itſelf to *a*; not to mention the too great Thickneſs of *k m* (as was obſerv'd before concerning *b c*) for this would be equally contradictory to Experience as the former.

79. Hence we are taught, that (*Tab.* VII. *Fig.* 2.) when the Fibre is cut through at *b* or *g*, or *k* or *l*, or wherever it be, each Part is drawn back to its Tendon to which it is faſtened, that is, to *a* and *p*; for Inſtance, if the Fibre be cut at *g*, the Machines between *a* and *f* are drawn to *a*; and thoſe between *g* and *l* to *p*; and thus we ſee, that by this means the Cut made through any Muſcle is viſibly larger than the Knife which made it.

80. From whence we may conclude, that on both ſides of the Cut, whether at *g*, *b* or elſewhere, there muſt remain ſome Machines unwounded, which have in them a contracting Power, notwithſtanding the Separation; and by this means the Fibre is drawn inward, or contracted, after it is cut through in any Part.

81. For if either Side ſhould be left deſtitute of theſe Machines, ſo that none were to be entire or uncut, the Conſequence muſt be, that that Side ſo deprived of theſe Machines, could not be in a Condition to contain the Matter which is the Cauſe of the Fibre's ſwelling; and conſequently the Fibre could not be actuated by any Power which would draw it towards its Tendon.

82. But ſeeing it is ſcarce poſſible to cut a Fibre through ſo near *a* or *p* (*viz.* at *m* or *n*) but that the Parts, as we find by Experience, do ſhrink on both ſides, as well the ſhort ſide as the long, to their reſpective Places.

83. It follows then, that how little a Part ſoever, ſuch as *a* or I, be cut off from the Fibre on one ſide, ſeeing it ſhrinks back, it muſt neceſſarily contain ſome Machines, at leaſt one entire one, in it ſelf.

84. And conſequently from hence we may plainly conclude, that the Machines, whereof the Fibres are compoſed, muſt always be, each of them in particular, ſmaller than the Part cut off; and therefore of a wonderful Smallneſs.

85. From whence then it follows, that the Number, at the ſame time, of theſe Machines, if the Fibre be of any conſiderable Length, muſt be very great.

86. *Borelli* (from whom the Reader may receive ſufficient Satisfaction, concerning the Multitude and Minuteneſs of theſe admirable Mechaniſms, *Prop.* 115.) maintains, that ſince every Fibre is ſmaller than a Woman's Hair; each Cavity A, B, C, D, E (*Tab.* VII. *Fig.* 1.) which being contracted, forms a Machine, *a*, *b*, *c*, *d*, *e*, muſt therefore be finer than the ſaid Hair.

87. Now

87. Now if theſe Machines be as broad as long, each Fibre will contain as many of them lengthwiſe, as there can lie Hairs breadth-wiſe on the ſaid length of this Fibre.

88. But according to the Calculation of the ſaid *Borelli* (*Prop.* 115.) fifty Fibres, placed breadth-wiſe by one another, do not amount to the ſpace of one Inch.

89. Wherefore, according to this Computation, fifty of theſe Machines muſt go to conſtitute a Portion of a Fibre of one Inch in Length.

90. But for Caution ſake, and to keep within Compaſs, that Author does not calculate above twenty Machines for every Inch of Fibre.

91. Which Calculation we may ſafely allow him; becauſe if any one may think it more convenient to imagine theſe Machines not to be altogether as broad as long, here is room enough to humour any ſuch Conjecture: For by this means, theſe Machines will have their Length exceeding their Breadth by $\frac{2}{3}$, *i. e.* they will be more than three times as long as broad.

92. To return then to the Force of the Muſcles: There appears here, in each Fibre, a new Inſtrument of the following Structure; *viz.*

Firſt, We ſee, in *Tab.* VII. *Fig.* 1. a great Machine W G, conſiſting of ſeveral ſmaller ones, as A, B, C, D, E, *&c.*

Secondly, That they are ſo formed, that each little Machine, A or B, being contracted by a particular Force, into Circles or Squares, or other Figures, *i. e.* expanded, as at A or B, *&c.* or otherwiſe (in another Form) at *a* or *b*, *&c.* contributes its ſhare towards raiſing the Weight T.

Thirdly, That being joyned, or linked, to one another at *a*, *b*, *c*, *&c.* they do likewiſe aſſiſt each other in raiſing the ſaid Weight.

Fourthly, When this Machine, *w g*, conſiſts of more or fewer little Machines, as *a*, *b*, *c*, *&c.* which operate here at the ſame time, the Weight T muſt accordingly be raiſed to a greater or leſſer Heighth (as the Number of Machines are multiplied or diminiſhed) and conſequently the ſame Weight T, will be moved with greater or leſs Velocity: For Inſtance; if there be ten times as many little Machines, contracting themſelves, the Weight T will be raiſed ten times higher; and at the ſame time, it will acquire ten times more Velocity.

93. All theſe Properties being ſo uſeful and neceſſary for a right Conception of the Motions of the Muſcles; and being a neceſſary Conſequence reſulting from their Structure; we ſhall endeavour to demonſtrate them by a Machine (adapted by Mechaniſts to other ſort of Uſes) which ſeems to have a pretty near Reſemblance to the Nature and Office of the Muſcles in general, and to give the beſt Light into this Matter.

94. Let us then ſuppoſe a Machine (*Tab.* VII. *Fig.* 4.) in which a Weight T, hangs at a Cord, which being wound about the Pullies 1 *a*, 2 *a*, *&c.* and 1 *b*, 2 *b*, *&c.* in the manner deſcribed by the ſaid Figure, is terminated and faſtened to the Nail *d*.

Then to each Pulley, at 1 *b*, 2 *b*, 3 *b*, 4 *b*, let there be ſuſpended an equal Weight, *g h m n*; which four equal Weights, preſſing altogether downwards, the Weight T will be thereby raiſed up and kept in Equilibrio.

95. Now

95. Now we may see in this Machine of Pullies, all the same Phænomena which have been manifested in the Muscular Fibres (92.); namely, that the whole Structure consisting of many little Machines, each does, by a proper Force, bear a respective Part in raising the Weight *t*; which altogether united, accumulate their Powers so as to prove mutually assisting the one to the other.

96. For if the Cord be carried only from *t* through 1 *a*, 1 *b*, and terminating at *e*, be there fastened to a Nail; we have a Machine, which acting by the sole Power of *g*, raises *t*. And in case the Cord be continued from the Nail *e*, on to the Pullies 2 *a* and 2 *b*, and be fasten'd to another Nail at *f*; this will be a second Machine acting by the Power *h*; which, if it be joyned to the first, will help to raise the Weight *t*.

97. If these Machines and Weights be multiplied, by continuing the said Cord farther on thro' 3 *a* and 3 *b* to *i*, and from thence thro' 4 *a* and 4 *b* to *d*, and so on, and a distinct Weight suspended to each, as *m* and *n*;

We shall have a great Machine produced from all these little ones; in which the three first things expressed in § 92. and repeated in § 95. will occur.

98. We see likewise, that the fourth thing described (§ 92.) which seems to be of the greatest Importance in this Muscular Demonstration, does here meet with an exact Resemblance; *viz.* by how much the number of little Machines is multiplied, by so much the more swiftly will the Weight *t* be raised up.

99. This is easy to be apprehended by Consideration, without the Circumstances of Demonstration; for if *g* only acts on the first Machine, which is supposed to end at *e* (96.) and the Center of the Pulley 1 *b*, being first at *r*, is drawn down to 1 *b*, so that it has twice 1 *b r* added to its Length, in a determinate space of Time; suppose in one Pulse or Second of a Minute, the Weight *t* will be raised to T, in the same space of Time the heighth of *t* T, which is equal to twice 1 *b r*.

Because the Pulley 1 *b* being thus run down from *r* to 1 *b*, the whole Cord, 1 *a*, 1 *b*, *e*, passes thro' the Pulley 1 *a*; which Cord retains, as we see, on each of the two Sides, *viz.* on the Side 1 *a* 1 *b*, and on the side 1 *b e*, the length of 1 *b r*; and consequently is twice the length of 1 *b r*.

Now in proportion to the quantity of Cord running thro' the Pulley 1 *a*, the Weight *t* must be raised from *t* to T; which must necessarily be twice the length of 1 *b r*.

100. If now we joyn the Second Machine, the Cord of which ends at the Nail *f*, with its particular Weight *h*, it may be easily (96.) inferred, that when both the Powers *g* and *h* concur in their Operation, to draw down the two Pullies 1 *b* and 2 *b*, from *r* and *r*, which are above (the length of 1 *b r* or 2 *b r*, which are equal) in such case, I say, it may be inferr'd, that four times the Length of 1 *b r* passes thro' the Pulley 1 *a*, exactly in the same space of Time; as may be seen by the four Cords, A, B, C, D; and consequently, that the Weight *t* will be raised to T, the heighth of 1 *b r*, multiplied by four, in the said space of Time.

101. If

101. If therefore theſe Machines and Powers, *m*, *n*, *&c.* were to be further multiplied, and all the Weights drawn down together in one Second of Time, it is plain that the Weight *t*, according to the number of Machines, muſt always, in the ſame ſpace of time, be raiſed higher; and conſequently move with greater Velocity.

And thus what is ſaid (92.) concerning the Force of the muſcular Fibres, is demonſtrated in this Machine.

102. Now, ſince this Machine of Pullies operates after this manner; thoſe who are verſed in *Mechanics* know that it is endow'd with the following Properties.

Firſt, That altho' we take a greater number of the ſeveral little Machines, and the Weights *g*, *h*, *m*, *n*, that draw them, yet they, joyned all of them together, will not be able to raiſe or poiſe in Equilibrio a greater Weight than *t* or T; which *g* only, operating by itſelf, cou'd poiſe the ſame way.

Secondly, But the Velocity, wherewith the Weight *t* riſes to T, will, by the Multiplication of theſe Pullies, be proportionably augmented; *viz.* by how much the number of theſe Pullies are encreaſed, by ſo much ſwifter will the Weight *t* riſe up to T.

103. To prove this, let us ſuppoſe the Pullies, 4 *b*, 3 *b*, 2 *b*, 1 *b*, (*Tab.* VII. *Fig.* 5.) to be each of them brought inwards to *r*, *r*, *r*, *r*, by the Gravitation of the Weights T, T, falling down to *t*, *t*; ſo that the Pullies on each ſide, to wit, 1 *a*, 2 *a*, 3 *a*, 4 *a*, may be in the common ſtreight Line *d* Q, indiſcriminately equal with the others, 1 *b*, 2 *b*, 3 *b*, 4 *b*; the ſtreight Line, *r*, *r*, *r*, *r*, paſſing directly thro' the Centre 1 *a*, from thence thro' 1 *b*, at the Center, and ſo on; in this State the muſcular Fibre *d* Q is to be apprehended to be extended to its full Length, and conſequently inactive; and each little Space, *d d* R R, R R S S, S S B B, and B B Q Q, will perfectly repreſent the little Machines of a Fibre which is in the State of Reſt.

But if now the Side *d* R be extended both ways to *d* D R, the Space *d* D R R D *d* will in ſome meaſure give us a Repreſentation of one of the Machines of a muſcular Fibre inflated or ſwelled up, in performance of its Function; becauſe the Cord by which the Weight T T is ſuſpended, is raiſed ſo high by the ſaid expanſion or ſwelling, and ſhortned at the ſame time ſo much below: By this means we receive a groſs Conception of the Action of the Fibres.

104. Since therefore the Properties enumerated (102.) are very fitly applicable to this Machine of Pullies, as well as to every Fibre, which it is purpoſely adapted to repreſent; it occurs, that the *Sixth* Obſervation ſhou'd here meet with an Application.

105. Namely, that in order to compute the Force of a Carnous Fibre, we muſt, according to what has been lately proved, multiply the Force of a ſingle Machine of any Fibre, by the number of all the little Machines of the ſame Fibre.

106. Now *Borelli* computes, (*Prop.* 124.) that each of the Carnous Fibres of the *Deltoides*, *viz.* G W (*Tab.* VI. *Fig.* 1.) is two Inches in length.

107. And,

107. And, according to § 90. each Inch contains the Number of 20 little Machines; five only (for Example sake) are marked here on the Fibre G W; consequently the whole muscular Fibre G W, being two Inches long, contains 40 of these little Circles, or rather little Globes.

108. Each of these little globular Machines, G M (59.) can exert a Force of 223 Pounds, towards raising T, or a Weight of 55 Pounds, which hangs at the Elbow; because (by § 102, and 104.) one sole Machine, G M, can act as much as 40 in making an *Equilibrium*.

109. So that by multiplying the Force of 223 Pounds (which one sole Machine G M exerts) by 40, or the Number of small Machines in a single Fibre of the *Deltoides*, we discover the Force of the whole muscular Fibre G W; *i. e.* 40 times 223, or 8920 Pounds.

110. Now since this *Deltoides* is suppos'd to consist of two Plumiformar Muscles, each containing two distinct Sides, or Ranges, of Fibres, as G V P and G P W, in the Muscle G V P W, as also H Q Z and H Q L in the other Plumiformar Muscle H Z Q L, in all four Sides (each Side here being represented by a * single Fibre G W) we must multiply (109.) this Sum 8920 by 4, in order to find the Force of the whole *Deltoides*, which will then produce a Force equal to 35680 Pounds.

111. Now tho' this proves such a Force in this Muscle, as perhaps might seem incredible to a Person not conceiving the Demonstration; and tho' this Force itself be more than sufficient for our Purpose, yet we shall however subjoin the Demonstration by which *Borelli* makes appear a Necessity of even doubling this Force.

112. *Viz.* It is obvious to Persons skill'd in Mechanics, that a Cord K T (the Weight K, *Tab.* VI. *Fig.* 6. being suspended to one end of the Cord, the other end being at the same time fastened to a Nail T, which renders it there immoveable) sustains as great a Weight, or Force, by the Suspension of the Weight K alone, as if it bore double the Weight of K.

113. This is manifest; because the Nail T contributes as much to the straining of the Cord K T, as if the said Cord K T, had another Weight, *m*, equal to K in Gravity, hanging at the other end, which is supposed to be carried round the Pulley *r*; for this last Weight K may be perceived to be as well Balanced, or kept in Equilibrio, by the Nail T, as by the other Weight *m*, equal to itself.

114. They who desire to see this Matter demonstrated more at large, may consult the aforenamed *Borelli's* Ingenious Treatise, *De motu Animalium*, in the 10*th Chap.* of the First Part; it will answer our present purpose, if these Matters be made merely intelligible, for the use of such as are not thoroughly versed in Mathematics.

115. Now to apply this to the Muscles (*Tab.* VI. *Fig.* 1.) it is plain from what has been said, that the Muscles there described, do represent a sort of a Machine of Pullies; one end of the Fibres G V, G W, Z H, H L being

* *Vid.* Prop. 102. where one Machine keeps the Weight T in *Equilibrium*, and 100 Machines can do no more.

fastened to the Tendons, V P W and Z Q L, which adhere as immoveably to the Bones, as the Cords in the Machine of Pullies do to the Nails *d*, *d*; whilst the other, and moveable Ends of these Fibres G V, G W, Z H, H L, do each of them exert a Force (62.) equal to 223 Pounds; or the Power of each of these moveable Ends is equal to the Weight *q*, which is supposed to weigh 223 Pounds: But all these four Fibres operating together, will balance a Weight of 892 Pounds.

116. If, according to § 112. this Force be doubled, the Force which this *Deltoides* exerts, by the Position of each of its Fibres, amounts to 446 Pounds; and the Forces of all four acting together, to 1784 Pounds, besides the Multiplication of this number by 40, which we are going to speak of, and concerning which mention has been made already, § 63.

117. And since we have hitherto supposed, that each Fibre, in these Demonstrations, is endowed with one or more Machines, like G M; and forasmuch as, according to § 102, and 104. one such Machine, as G M, can balance as great a Weight as all the 40 Machines of the whole Fibre G W; it will appear, since the Force exerted by each Machine is equal, that in order to Calculate, or make an Estimation of the entire Force of the whole *Deltoides* (or of the four muscular Fibres constituting it) we must multiply this Number 1784 by 40, or the number of Machines in each Fibre, which amounting to the Sum of 71360 Pounds, is the Force which (according to § 102, and 104.) the *Deltoides* is capable of exerting.

118. Here this (*Tab.* VI. *Fig.* 1.) may likewise serve, in some measure, to demonstrate from the foregoing Principles, the Force of the Muscles called *Glutæi*, when they exert their Power, in raising Weights suspended to the Heels.

119. The *Glutæus Major*, which is the Muscle we are to speak of, is, according to *Borelli*, (*Prop.* 83.) made up like the *Deltoides* of Plumiformar Parts.

120. Suppose then B to be the Heel; *d* the Knee; K E F A the round Bone in the upper Part of the Thigh; the Weight to be raised by the Heel B, must, according to *Borelli*, (*Prop.* 85.) be computed to weigh 65 Pounds.

121. We perceive here, that the Shin and Thigh-Bone together (which are represented by B C) comprehend in length 31 Semi-diameters of K C, or the round Bone of the Thigh.

122. If therefore an Equilibrium be to be made betwixt the Tendon D K I and the Weight T; the said Tendon cannot be raised to X, by a Force less than 31 times 65, or 2015 Pounds.

123. And if this Force is to be exerted by two other Tendons, D H and D G; each of them will not only bear the half of 2015 Pounds; but because they draw in an oblique Direction, will so much exceed the half, or 1007½, as D G exceeds D X in length.

124. But *Borelli* says, in relation to that (*Prop.* 83.) that the *Angles of Obliquity* X D G and X D H are each of 45 Degrees.

125. Consequently (by the Tables of *Sines*, and casting away the five last Cyphers) As the Radius, 100: To the Secant of 45 Degrees, 141: : So 1007½: To 1420 Pounds.

126. So that each of the Tendons, D G and D H, being drawn obliquely, must be acted on as if a Weight of 1420 Pounds, like D P or D Q, were suspended

ſuſpended over the Pulley P; otherwiſe their Force will not be equal to the Weight or Power which draws K D, according to the Direction K X.

127. And again; at D G, there are two other oblique Fibres, G W and G V: Theſe, to operate in like manner with the former, will each of them contribute a Force ſufficient to raiſe the half of 1420, *viz.* 710 Pounds, gravitating perpendicularly in the Direction G P.

128. But becauſe they draw obliquely, the Force which draws according to G W, will ſo many times exceed 710 Pounds, as G W exceeds G S in length.

129. According to *Prop.* 83. of *Borelli*, the Obliquity of this Angle is 8 Degrees.

130. Therefore by § 58,

As the Radius 100000 : To the Secant of 8 Degrees, 100952 : : So 710 : To $716\frac{8}{10}$ Pounds.

131. Therefore each Fibre G W, repreſenting here one entire ſide, G P W, of this Plumiformar Muſcle, muſt in the caſe before us raiſe a Weight of $716\frac{8}{10}$ Pounds.

132. But further, according to *Borelli*'s Computation (*Prop.* 125.) each of theſe Fibres is of the length of three Inches; conſequently each contains in its Compoſition 60 Machines.

133. Therefore let $716\frac{8}{10}$ (the Force found according to § 130.) be multiplied by 60.

134. The Product of $716\frac{8}{10}$ multiplied by 60, or 43014 Pounds, equal to the Force which this one Muſcular Fibre G W (or even the whole ſide of one Plumiformar Muſcle, to which this Fibre is ſuppoſed to be equal) exerts towards raiſing up a Weight.

135. Now it being taken for granted, that the Muſcle D Q P, conſiſts of two of theſe Plumiformar Muſcles G W P V, and H L Q Z, containing betwixt them, four ſides: Therefore theſe two Muſcles exerting a joynt Force, will (by means of their four Sides, or four ſuch Fibres as G W) exert a Force equal to four times 43014, or 172056 Pounds.

136. But ſeeing that this Muſcle does adhere at one end to a Bone, as if it were a Nail T, (*Tab.* VI. *Fig.* 6.) by its immoveable Tendon; and is only moveable, ſo as to carry a Weight, like K, at its other end; this Force is therefore yet to be doubled; becauſe the Muſcle, by its being faſt'ned at one end, ſuffers as great a Strain, as if it had an equal Weight ſuſpended over a Pulley, at the other end.

137. Wherefore doubling 172056 (the great Force of this Muſcle) we find that 344112 Pounds does correſpond to the Power that the *Muſculus Glutæus Major* can exert in performing its Function.

138. And this is what we take to be ſufficient to inſinuate a general Idea of theſe Matters: If any one deſires to ſee a more accurate and exact Account, he may meet with more ample Satisfaction in the ſaid Book of Signior *Borelli*. We have been more brief in this Inſtance of the *Glutæus*, becauſe we judged it a needleſs Trouble to repeat Verbatim what has been demonſtrated more fully before in the Caſe of the *Delto'des*.

139. We might here conclude this Work, of Demonstrating the Force of the Muscles, if some Objections did not intervene, which might hinder Persons not thoroughly skill'd in Mechanics (for whose sake we condescend to this prolix way of Demonstration) from acquiescing in the Proofs that have been deduced from Mechanical and Mathematical Observations: These Objections therefore we shall endeavour to obviate by suitable Remarks or Observations

140. The first Difficulty that may perhaps be started, is, that in *Tab.* VI. *Fig.* 1. we have represented one single Muscular Fibre in the room of an innumerable number of others, which constitute the whole side of the Plumiformar Muscle G W P: Moreover, it seems agreeable to Observation, that one of these Plumiformar Muscles, represented by G V P W, is not confined to two Plane sides, G W P and G V P; but diffuses its carnous Fibres, Pyramid-wise, in great multitudes from a Point, as G, like a *Verticillum* or Wheel, in the shape of the Extremity of the inverted Pyramid, V G W: This happening from all the Points, G N, *&c.* of the middle Tendon G D, these Fibres do in no fashion represent a Plane; but constitute the Figure of a perfect Body, with Length, Breadth and Thickness.

141. In answer to this; to shew that our supposing these Muscles to consist of Plane sides (which is a method we have judg'd most expedient to convey these Demonstrations to the Understanding) does not in the least alter or enervate the Force of the Demonstrations; and to prove that the same prodigious Force wou'd manifest itself from every particular Muscular Fibre, tho' the Calculation had been made from a greater number of the Fibres of a verticilated Body, instead of the two Fibres G W and G V.

Let such as read this consider, *First*, that as we have only taken two Fibres, G W and G V, for the two sides of the Muscle, *viz.* G P W and G P V (whether solid or plane) so likewise we have only ascrib'd half of the Force of the whole Muscle, G V P W, to each of these two Fibres, as by (61.) where the Force of one carnous Fibre, acting according to § 59. was found to be equal to a Weight of 223 Pounds; to represent the Force of the whole Muscle G V P W, we were under an Obligation of doubling 223 Pounds; so that the full Force of a Muscle is represented by the Force of two Fibres, or 446 Pounds; this is the Foundation of what is to follow.

142. Now, for the benefit of unexperienced Persons, we thus compute, that the Force of a Muscle is the same, whether this Force be imagined to be center'd in two Fibres, as G W or G P; or whether the Force be distributed amongst an infinite number of Fibres, contained in the space G V W P; which Space you may imagine, if you please, to be occupied by a Body consisting of Length, Breadth and Thickness, and not a mere Plane Figure.

To this end, suppose (*Tab.* VII. *Fig.* 6.) a Weight D (not unlike *Tab.* VI. *Fig.* 4. and § 48.) of 442 Pounds, suspended at a Cord D O S, and supported by another equal Weight *q*. Now if we take away this Weight *q*, and balance the Weight D by a number of other Weights fastened to oblique Cords, G, A, P, *&c.* each of which bears a Weight *m, h, g, p, n, &c.* on this Account.

If

If we now conceive the Cords to be so order'd, that there may be imagined 100 Points, like G, A, P, *&c.* in the length of the Cord G O, to which the oblique Cords, G W, G Q, A B, A E, *&c.* are fast'ned: And moreover, that there are about each Point, as G, or A, or P, *&c.* not only two Cords, as here at G and A, but imagine 10 to be placed round the Circle, like the Spokes of a Wheel, or *Verticilla* of a Plant; four such Cords we have described to issue from the Point P, *viz.* P V, P T, P H, P R.

Lastly, let it be also supposed, that the Weights *g, h, m, n, p,* are equal to one another; and that the oblique Angles, M G N, B A P, R P O, *&c.* which each oblique Cord makes with G O, are also equal, and of 8 Degrees each.

It is therefore demanded, what the Weights *g, h, m, &c.* drawing obliquely, amount to? And how great a Force they must altogether, in Conjunction, exert, in order to Balance the aforementioned Weight D.

143. To find this, it must be considered, that we have imagined the Weight D to be drawn by a thousand Weights, equal in Gravity to one another: Since (according to § 142.) there are supposed to be 10 obliquely drawing Weights, and also we have imagined 100 such Points as P.

144. Wherefore each little Weight *g, h, m, &c.* must raise one thousandth Part of the Weight D; or according to (142.) a Gravity of $\frac{442}{1000}$ Pounds, which each was able to sustain in the direct or perpendicular Line G O.

145. But considering that they draw obliquely, each such Weight as *m,* must exert a Power so many times greater than $\frac{1}{1000}$ of D, or than $\frac{442}{1000}$, as the Line M G is longer than N G.

146. Now forasmuch as the oblique Angle N G M, of each is, according to *Borelli* (57.) of 8 Degrees; therefore by (58.) if G N be 100000, G M must be 100982: It follows (if they operate proportionably) as G N: To G M:: So $\frac{442}{1000}$: To $\frac{446}{1000}$.

147. So that each little Weight, as *m,* must have the Gravity of $\frac{446}{1000}$, which is the first *Postulatum* (142.)

148. Now the Method, by which the Power of all these little Weights, when they exert themselves in order to raise D, or 442 Pounds, is to be discover'd, seems to be the plainest thing in the World: For do but multiply the Force which one of them, as *m* for instance, exerts, *viz.* $\frac{446}{1000}$, by the number of all the little Weights, that is by 1000, and the Product is the Force of them all acting together, which appears to be 446 Pounds; the same which was demonstrated by the joint Action of only two Fibres.

149. By these Weights and Pullies, you may imagine all the Power which is exerted by every single Fibre of a Plumiformar Muscle, such as G V P W (*Tab.* VI. *Fig.* 1.) to meet with a just and analogous Representation.

150. For you may observe, that the Weight of 446 Pounds is as exactly equivalent to the Power exerted by this whole Muscle G V P W, when you have supposed it made up of a thousand Fibres, as when before, according to (61.) we imagined it to consist of only the two Fibres, G W and G V.

151. And from hence, by a little attention, what we have said above, at § 141. may appear exceeding plain and easy to any ordinary Capacity: Namely, that altho' the constituent Fibres of a Muscle were imagined to

amount

amount to ten, or a hundred, thousand, or the highest Number you can suppose, the very same Force, of 446 Pounds, will always, by these Methods of Calculation, be the Result of the whole.

152. And to proceed yet further; we shall find the *Deltoides* exerting the very same Force; tho' we suppose (*Tab.* VI. *Fig.* 1.) to be an unjust Representation, on the account of the Number of the Plumiformar Muscles; as if we imagine the *Deltoides* not to be confined to two, as represented by G V P W and H Z Q L; but contrary-wise, to be endowed with many of these Plumiformar Parts; yet we shall easily perceive, that the Force, or Power of it being calculated according to the foregoing Rules, the whole will be exactly congruous to the Power or Force already demonstrated.

153. And thus the Objection, which seemed to oppose this Hypothesis with the greatest Appearance of Reason, vanishes; and the Difficulties, under which some might labour to conceive the possibility of two such Fibres, as G W and G V, being able to support together 446 Pounds, or each of them singly half of that Number, are quite cleared and taken away: Especially when it is consider'd that we have only all along laid these things down by way of Supposition; but by these *Data* however, the whole Force of the Muscle comes to be exactly accounted for: The Consequence proving the same, whether we suppose the Muscle constituted of a Million of Fibres (as in all appearance there are a vast Number) or of only two.

Let the Figure or Structure of these Muscles be what it will, this Method may serve for a Sample to shew by what Means their Power and Force are to be investigated.

154. In all these Reflections, *viz.* on the prodigious number of Fibres; on the curious and peculiar form of the Muscles, which represent Feathers joyned to a Tendon, as to a Quill (on which Topick consult *Tab.* V. *Fig.* 10. where the Structure of the *Deltoides* is drawn from Steno's *Myologia*;) and, lastly, on the prodigious and almost incredible Force exerted by them; in reflecting, I say, on all these things, the adoreable Wisdom of the Great Creator must most singularly manifest itself.

Steno represents the *Deltoides* consisting of 12 single Muscles, that is six Plumiformar Muscles on each side: And if you imagine the empty White Spaces, above and below, to be full of carnous Fibres (as *Steno* affirms, *p.* 53.) how vast must the Number be conceiv'd to be? And as to the Force, which *Steno* demonstrates them to exert, according to his Form, it cannot be much less than he asserts. But we have chosen rather to follow *Borelli* in our Representation, (according to *Tab.* VI. *Fig.* 1.) because by this means we apprehend our Demonstrations better adapted to Capacities unexperienced in Mechanics.

155. But to penetrate further into the prodigious Number of the Fibres, and to discover, as far as possible, the wonderful Design of the Creator, we need only observe (to keep to the instance of *Tab.* VI. *Fig.* 1.) that the two Fibres, G W and G V, are found to balance separately, a Weight of 223 Pounds (59.) that is jointly 446 Pounds; as they represent together, the whole Plumiformar Muscle G V P W.

If now, instead of two Fibres, we suppose (143, *&c.*) this Muscle to comprehend 1000 Fibres; each of these thousand Fibres will bear $\frac{446}{1000}$ of a Pound; that is not half a Pound to each Fibre. And

And if the Number of Fibres were to be imagined greater, the Weight ascribed to each, to bear for its Portion, wou'd prove much less: Or if the *Deltoides*, according to *Tab.* V. *Fig.* 10. instead of two Muscles comprehended six (154.); each Muscle could then have its share or burden, but $\frac{1}{3}$ of 446 Pounds, which is not quite 150 Pounds each: Thus the 1000 carnous Fibres constituting each Muscle, cou'd have to its share no more than $\frac{150}{1000}$ or $\frac{1}{2\frac{1}{6}}$ of a Pound.

156. Now who, apprehending this Structure of the Muscle, can think on it without acknowledging the Wisdom of the Creator? Who has made the Tendons tough and strong enough to bear, without breaking, the Violence of the Force which they are obliged to suffer in exercising the Qualities they are endowed with: At the same time, having regard to the Safety of the most fine and tender Fibres, by laying no more stress upon each of the Fibres in its Office than it is, by the Assistance of such a multitude of its Fellows, able to sustain, without the least Injury.

157. For the Weight which each Fibre sustains will be much less than $\frac{3}{10}$ of a Pound 155.) if the Number of Fibres in each Plumiformar Muscle much exceeds (as 'tis probable they do) 1000; which was what we supposed (155.) them to be.

It would therefore be worth any one's trouble, to investigate the number of Fibres in each Muscle, as near as possible; not only to clear the determinate Number of Fibres composing each Muscle (which might be done by those who with accuracy pry into dissected Humane Bodies) but also to adjust exactly how many of these Fibres, placed bredthwise, may be contained within the Space of an Inch. *Borelli* says (*Prop.* 115) that 50 Fibres thus placed, will scarce amount to an Inch: And as to the Number of Fibres in each Muscle, we may judge from the Flesh of Beasts, that many of these carnous Fibres make but a small Portion of such Muscular Flesh as we daily use in Food.

158. We shall cease to admire at what is advanced in *Tab.* VI. *Fig.* 1. concerning the Position that is here laid down, *viz.* that one sole little Machine, GM, of the Fibre GW (and so of the other Fibre GV) is able to support 446 Pounds, when we consider what follows.

The foregoing Propositions have made appear that the stress laid on each Machine, as GM, bearing not more than its Fibre GW, will not amount to $\frac{3}{10}$ or two Ounces and a half.

159. Thus the swiftness of the Motion imparted to the Weight T, by the contraction of the little Machines A, B, C, *&c.* (*Tab.* VII. *Fig.* 1.) where each of them are drawn up into the form of *a*, *b*, *c*, *&c.* will not appear so improbable; seeing that if there were no Weight, such as T, suspended, the conclusion (*viz.* that the Fibre to which T is suspended, must rise with the Velocity abovementioned) wou'd be in itself the most obvious thing in the World: Because, by the foregoing Proposition, the Weight is represented so small, that a single Fibre or Hair, can be put to no great stress to bear it; especially, considering that it has been already declared, that the Weight of 223 Pounds ascribed (59.) to a single Fibre (which is the chief thing that can raise any Difficulty) is only thus supposed by way of *Hypothesis*; for the con-

veniency of conveying to the Mind such a just Idea of the Matter, as may do no wrong to the real Calculation.

160. Now since we have shewed before (109.) that tho' the Muscular Force be ever so much augmented by the multiplication of these little Machines; yet, their disposition is proved to be such, that they all acting together, cou'd not raise the Weight suspended to the Elbow, if it had been but one Pound heavier; and that the multiplying these Machines does only serve to encrease, or multiply, the Velocity of the Motion.

Therefore Persons not thoroughly acquainted with Mechanics may yet seem to question, how it can be possible that the Force of the Muscles is really augmented, when the Weight which is raised is in no wise encreased.

To answer this, they ought to be informed, that a really augmented Force is as much required to encrease the Velocity of Motion, as to raise a greater Weight with the same Velocity: This is what all Mathematicians know.

This also is made appear by the Pulley-Structure (*Tab.* VII. *Fig.* 4.) where the Augmentation of the Velocity with which the Weight T is raised, requires each time more Force and new Weights, as *m*, *n*, *&c.* See the 5*th* Remark, 102.

161. That this obtains in other Mechanical Instruments, is what Mechanists are convinced of, and what may be easily observed: For suppose (*Tab.* VI. *Fig.* 7.) A B to be a Balance or a Steelyard, turning about D, and the Arms A D and A B to be equal; as also, the Weights A and B: 'Tis very plain, that the said Steelyard A B being turned into the Position M K, the Weight A will run over the Arc A M, and the Weight B over the Arc B K in the same space of time; and that the Arcs being equal Parts of the said Circle, the Weights must likewise move with equal Velocity.

Therefore if the Weight B were to balanced, when its Gravity in encreased thrice as much as it was, or when two equal Weights G and H are added to it, the Weight A must necessarily be assisted by two others of equal Gravity, or have its Force multiplied by three, as we see it has when the Weights E and F are added to it. Again, if we wou'd make B move with a Velocity three times as swift as it had before, let the Point B be removed to C, so that D C may be thrice as long as D B: Wherefore, when the Machine turns, and A describes the Arc A M, the Weight C will describe the Arc C L, in the same space of time; which being thrice as great as A M, therefore the Weight C runs thrice as swiftly as A or B.

But to balance this Weight C, when it moves thrice as fast as B, it is plain that the Weight A must be multiplied by three, or receive the Addition of two other Weights, each equal to itself, such as E and F; otherwise it cannot raise up the Weight B, which, placed at C, is equal to B G H, which happens on the account of that Velocity, receives a threefold Augmentation.

Thus the Objection started in § 160. is removed.

162. Before I conclude, 'tis incumbent on me to beg that the experienced Mathematicians will excuse my Prolixity; not only in the Demonstrations themselves, but in consuming Time to answer such frivolous Objections as might be started by Persons unexperienced in these sorts of Studies; which renders the whole too long and tedious for expert Judgments.

But

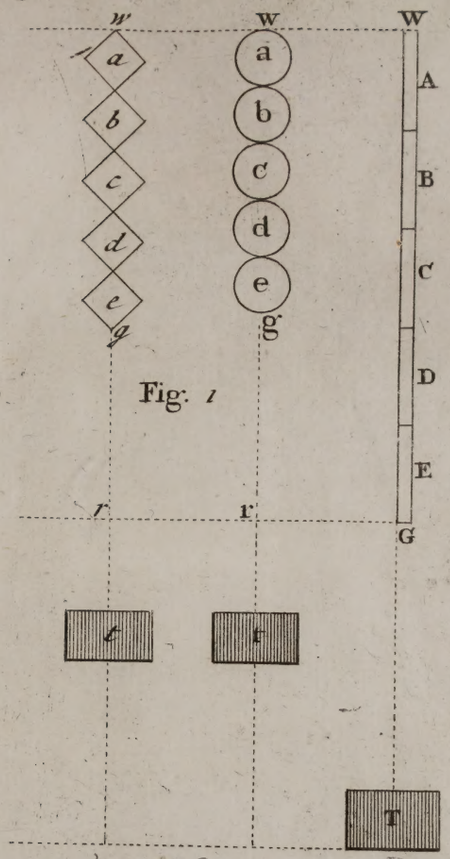


Fig. 1

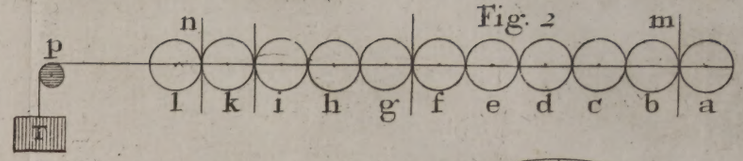


Fig. 2

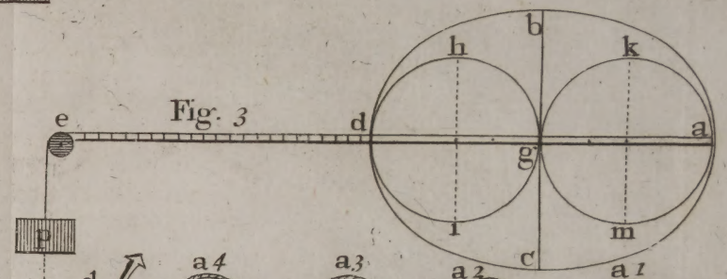


Fig. 3

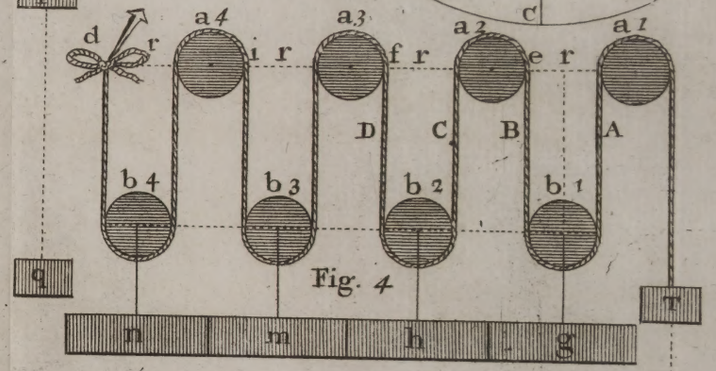


Fig. 4

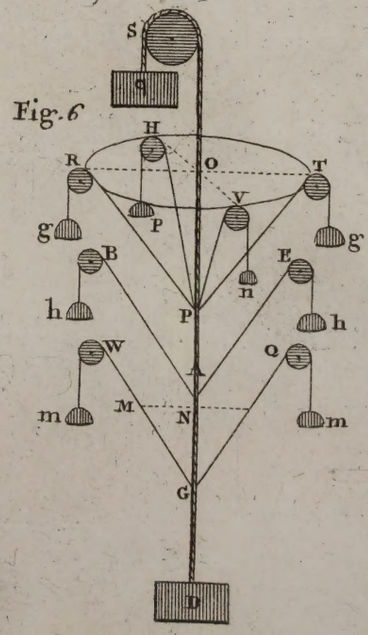


Fig. 6

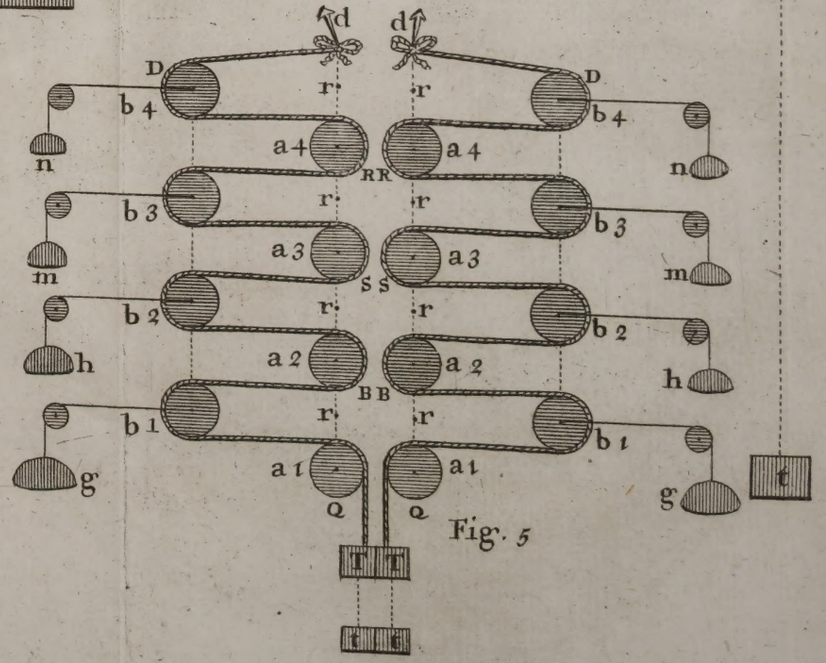
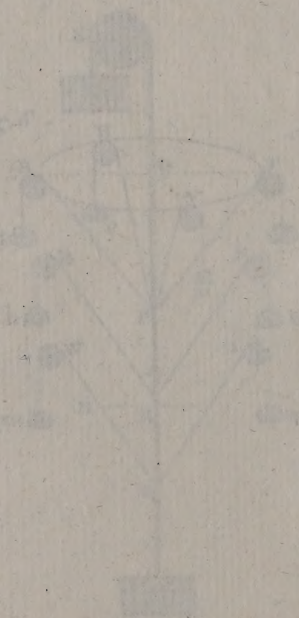


Fig. 5



But if they'll please to consider, that this Calculation is wholly devoted to the Use of unexperienced Persons, and not calculated for the Taste of nice Mathematicians, who are too well informed in these Matters already, to want such mean Helps; I hope I may obtain their Pardon. The Persons for whom these Demonstrations are collected, are such as being unexperienced, have not habituated themselves to heap up together any considerable Number of *Lemmata*, or previous Proofs, before they come to the Matter itself, whose Judgments cannot be informed in things of this Nature, without enlarging the Stile, and describing Particulars more verbosely; which is a Means, I have imagined, will convey my Designs more plainly to their Apprehensions.

They that desire to view this Matter, as it is more expresly and accurately handled and demonstrated, may have recourse to that well digested Work, *De motu Animalum*, written by the Great and Celebrated Mathematician, *Borelli*: whose Principles and Observations we have here made use of; endeavouring in the mean time, to render his Demonstrations intelligible, by the conciseſt and easiest Methods we cou'd devise, to such as have but little Knowledge of Mathematical Studies.

[*The End of the Demonstration of the Force of the Muscles.*]

Sect. XVI. *The Different Course of the Muscular Fibres.*

In order to have a just and true Notion of the various and different Courses of the Fibres, we shall represent to you a few Instances in *Tab.* VIII. *Fig.* 1. where, in the Muscle called the *Deltoides* A, you may observe the Fibres fast'ned immoveably upon the Shoulder C, and to the Tube or Bone of the Arm turning to the Joint of the Shoulder at D, letting the Arm hang downwards, as it is shewn here with all its Fibres extended in their utmost Length. But when these Threads between C and D are contracted with any Force, as you may see them in the other Shoulder at B; then the Arm must be lifted up, as at B E.

The Pectoral Muscle K, being likewise here inserted in the Breast-Bone, with one end of its Fibres at F, immoveably, and with the other end D, in the Tube or Bone of the Arm, moveably; it appears, that upon the Contraction of the said Fibres they would draw the Arm, bending it at the Shoulder Joint forwards to the Breast.

If we view the Course of the Fibres in the Muscle called the *Latissimus dorsi* A, A, (*Tab.* VIII. *Fig.* 2.) on each side, it appears that they draw the Arm downwards and backwards; for which reason *Anatomists* give it the name of *Ani-Scalptor*.

In the *Gasterocnemii* B B, which lie in the Calf of the Leg, and are fast'ned the one above, about the Knee at one end, as the other is below to the Heel-Bone by a strong Tendon C; it may be observed, that the Fibres run strait downwards, wherefore upon the contracting thereof, the Heel-Bone must be moved backward and upwards, and the Foot downwards. If one lifts up the Heel-Bone, and lays ones Hand upon the Calf of the Leg, one may feel the Muscles swell and contract themselves in that Place. These few Instances

may suffice to give any one a general Notion of the Motions of the Muscles by the Description of the Course of the Fibres whereof they are composed.

SECT. XVII. *Convictions from the foregoing Observations.*

THIS wonderful Structure of the Muscles seems to me of too great Importance, not to place them before the Eyes of such as are unexperienced in Anatomy, by the two Figures of the Muscles, as they lye upon a Human Body, before and behind. (*Tab.* VIII. *Fig.* 1, and 2.) taken from Dr. *Brown.*

CONTEMPLATION XI.

Of the Bones.

SECTION I. *The Transition to the Bones.*

NOW whatever Art and Wisdom appears in what has been said concerning the Body; and with whatever Lustre the things hereof may shine, how necessary and useful soever all its Veins, Nerves and other Parts may be; yet all this amazing Structure would be in vain, and the whole Body, like a wet Sack, would cling or stick together, and consequently hardly be in a Condition to exert any one Motion with Regularity, nor yet be able to remove one Foot out of the place it was in; (wherefore it might perhaps have represented an Ingenious and Well-composed Machine, but yet at the same time would be really nothing more than a very useless, weak, and pitiful Lump,) unless the Gracious Creator had at the same time vouchsafed to support it by the Stiffness and Hardness of Bones, and so render it proper to discharge its Functions.

SECT. II. *The Skull and Bones of the Head.*

THO' the Remarks that *Anatomists* have made upon Bones are numberless, we shall only here produce a few of the chiefest of 'em. And,

1. Can it be thought there was no Wisdom exerted, when we consider that the Brain being of so soft a Matter, might have been easily pressed and wounded by external Accidents, to the hazard of our Lives; to prevent the same, it is cloathed and encompass'd with a hard Substance made of Bone, which we call the Skull?

2. That this Skull does not consist of one only hard Piece, but of several Parts joyned together, which may be divided by a kind of intervening Sutures, to the end that they may be moveable and yielding in unborn Children, at the time of their Mothers Delivery; for want of which, Mother and Child might both perish.

3. That

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Fig. 1

Fig. 2

3. That such Moveableness ceases as the Children grow in Years, when it would otherwise be prejudicial, and then the principal use of those Sutures, is to maintain a Communication between the Membranes that encompass the Brain and the Skull.

We see a great Proof thereof from hence; forasmuch as at the Top of the Head where the Sagittal and Coronal Sutures cross each other, there is found an Opening between the Bones, which in New-born Children is all cover'd with a Membrane, upon which, if you lay your Finger, you may perceive the beating of the Parts in the Head; but in time the same is filled and closed by a solid Bone.

4. That the Skull, tho' every where of so solid a Substance, has yet Holes in it in all Places where it is necessary, to afford a Passage for the *Medulla Spinalis* and Blood-Vessels from the Brain; particularly, that there are found in the Ears so many Angles and Cavities, artificially hewn out, as it were in Bones as hard as Rocks, for the Reception of the wonderful Instruments of *Hearing*, placed in such an order as they appear to us.

5. That there is an Orifice in the upper Cheek-Bone, thro' which the Air passes by the Nose into the Lungs; and for want of which, no Child could easily suck, nor full-grown People themselves keep any Liquor or moist Food long in their Mouths.

To say no more, it is obvious enough to every one, how great the Inconvenience would be, if a Man were forced to breath thro' the Mouth only, and not thro' the Nose.

Now those who would take the farther trouble of considering the Bones of the Head in the minutest Circumstances thereof, and learn from Anatomy the Uses which the Diligence of Enquirers has hitherto discovered; might see, that among all the Number of them, that there is no Part, no Cavity, no Orifice, tho' ever so small, but what has its necessary Use; and that not only for the Ease and Well-being, but even many times for the Support of our precious Lives.

Sect. III. *The Back Bone.*

But now as the Brain is encompass'd with a Bony Case, that it may not easily be affected by any external Inconvenience; the like Defence seemed to be no less necessary to the *Medulla Spinalis* against all outward Harms; for that consisting of the soft Matter of the Brain, must be carried downwards in order to communicate the Spirituous Juice thereof, by the Nerves to many Parts.

To this purpose a hollow Tube of Bone, like that of the Leg, seems to have been sufficient, because it might have contain'd and secured the same against external Violence; but on the other hand, there occur'd an Inconvenience which must be prevented, namely, that the Body would remain as immoveable as if a Stake were run thro' it, and be entirely disabled from bending itself in any manner.

And again, if Joints had been made in this Tube that includes the Spinal Marrow, such as are in the Elbow, Fingers, *&c.* the following Inconveniencies would have happen'd.

First, That the Parts of this Tube making small Angles with each other, or being entirely bent down towards one another, the *Medulla Spinalis* must have followed such an Inflection, and the Course of the Nervous Juice would have been obstructed by these acute Angles; which of how great Consequence it is, is well known to those, who by the like Obstructions have not only fallen into Lameness, but even Agues, Putrefaction and Rottenness of the Bones, and have lost their Lives too thereby.

Secondly, Tho' none of these Inconveniencies should happen, yet the Body might by such sort of Joints be bended forwards, and in some manner backwards too, but by no means side-ways, as is plain in the Elbow and Fingers. Indeed if Articulations were to be made like those of the Shoulder or Hip; and that the *Os Rotundum*, or Protuberance of one Tube should turn or be moved in the Cavity of the other, it is easy to see that the Inflection would happen on all sides: But it is likewise true, that the Spinal Marrow could not suffer more in any Disposition; forasmuch as being obliged to run thro' the Thickness of such a Bone, it could not avoid being straiten'd and pressed by the Motion thereof, and soon render'd unfit for its Uses.

To prevent all these Inconveniencies, and to render the Body flexible on all sides, and yet to avoid such Constriction of the *Medulla Spinalis*, by making some little Angles; and chiefly to secure the same quite round, against all Occurrences, let the most skilful Engineer, or the greatest Mathematician, consider with himself, whether he could better solve this important Problem in Mechanics, and attain all these Ends by a more perfect Structure than that which the adoreable Wisdom of the Great Creator does here set before us. Those who desire a short Conception thereof, let them view *Tab.* IX. *Fig.* 1. where the Back-Bone is represented, consisting of a Number of little *Vertebræ* placed upon one another; each of which has a great Hole in the middle, in order to let the Spinal Marrow pass thro' it, by which means all of them together compose a hollow Tube from Top to Bottom; which being inflected, either right forwards or on either side, do, by reason of the smallness of the said *Vertebræ*, scarce make any Angles, or very little ones: In the same manner as it were, as in the Multangular Figure A E B, F, C, G, D (*Tab.* XI. *Fig.* 2) in which we see little and insensible Flections, where if the sides were made a little smaller, or, if instead of A E, two or more other sides were taken, the Figure would be very near circular; that is to say, without any Angles at all, at least, any that are perceptible to us.

Now, since it appears from hence, that if we inscribe a Polygone in a Circle of fewer and greater sides, as A B, B C, C D, the Angles A B C, B C D, *&c.* are much less and more acute than the Angles A E B, E B F, *&c.* which are made when the Circumference of the Polygone Figures consists of more and smaller Parts: We see likewise, that to prevent such acute Angles, it was here necessary, that the *Vertebræ* should be very small, and therefore very numerous.

Sect. IV. *The Uses of this Structure of the Back-Bone.*

Now can any one imagine that the Division of this Tube into such small Parts as those of each *Vertebræ* (which was just necessary in this place and no where

where else) could have been made only here, and in no other Parts of the Body, without the wise and premeditated Purposes of a Great Creator?

Moreover, because this Back-Bone was not to be moved by Joints, but inflected without Angles, we see in the Figure above mention'd, how this is most regularly brought about, by fast'ning each *Vertebræ* to the next above and beneath it by an intervening Cartilage; from whence the three following and so necessary Uses do result:

1. That by the intervention of such a Cartilage, the *Vertebræ* are hinder'd from rubbing and wearing out each other.

2. Forasmuch as in the bending the Back-Bone (on the Right side for instance) the *Vertebræ* on the same side must be brought nearer to each other, and upon the Left and opposite side at the same time must recede farther from each other: That this Cartilage has such a Faculty as to be able to serve for both Purposes, and to permit that the Back-Bone, by the mutual approach of the *Vertebræ* at the times of bowing or bending on the Right side, are pressed something closer together, and so render'd as it were thinner; and at the same time on the Left side proportionably extended, and so became as it were thicker.

3. And that which is particularly required here, is, that this Cartilage should likewise have an *Elater* or Expansive Faculty, which, upon its being compressed on the Right side, should cause it to rise up again; and when extended on the Left side, should likewise contract, or draw it in again.

Thus this Cartilage is not only proper to render the Inflection of the Back-Bone easy and convenient; but likewise to exert itself with a sensible Force for the Reduction of the same into its natural State after Inflection: The greatest Mathematicians having enquired into this with the utmost Diligence, have been obliged to acknowledge it for a wonderful piece of Work. *Borelli, Prop.* 58. *De motu Animalium* calls it *Artificium Structuræ Spinæ Dorsi*, or the *Artificial Structure of the Back-Bone*, and begins his Enquiry by ascribing these and such like Matters, to the *Wisdom of the Divine Architect*.

Sect. V. *The Vertebræ.*

We shall pass by the Wonders that might be observed in the Eminences or Heads of the *Vertebræ*, into which the Muscles are inserted for Motion; and in the Holes that are therein for a Passage for the Blood-Vessels; as likewise the Cavities that are between every two *Vertebræ*, and thro' which the Nerves that are derived from the *Medulla Spinalis*, pass to their respective Parts: the least of all which may furnish us with sufficient Matter of Astonishment at the Wise Designs of the Creator.

Particularly the Structure of the two highest *Vertebræ* of the Neck is very wonderful, which, because the Case does here require it, and to the end that the Motion of the Head may not be obstructed, are each of 'em of a different Figure; and the second of 'em has an Eminence which serves for a Pin, upon which the Head may turn by the means of the first *Vertebræ*. He that desires to be farther instructed herein, may consult the Books of *Anatomy* which are in every ones Hand; and if he be in earnest in his Enquiry into the Glory and Greatness of his Creator, make the right Use thereof.

Sect.

Sect. VI. *The Ribs.*

Not to dwell too long upon the use of the Ribs, which form the Space and Cavity of the Breast, in order to leave room enough for the Heart and Lungs to move in, and at the same time to defend the latter from all external Violence: Let any one ask himself, whether it be owing to *mere Chance*, that these Ribs, in the Part where they are fastened to the Cartilaginous Breast-Bone, are likewise composed of a Cartilaginous Substance, to the end, that when they move at Respiration or drawing in of the Breath, they may be more easily inflected by the Muscles; and after that the Operation of the Muscle ceases, they may, by their own Elastick Force, return to their former State, and thereby contribute very much towards Breathing.

Concerning their Power and Action, you may see what the Learned *Borelli* has said in his Second Part.

Sect. VII. *The Hip-Bones.*

To mention cursorily the rest of the Bones, and particularly the Hip-Bones, with whose most necessary Service we should be sufficiently paid, if they were of no other use only than to secure and strengthen the Wombs of Women, from whence all Mankind receive their Birth; besides, that they afford both to Men and Women an immoveable *Fulchrum*, or Support, to the Thighs, Legs and Feet in bearing the whole Body: It should seem therefore that nothing remains, but to give some account of the Structure of the Arms and Legs, of which, as also of their Articulations and Joints, something has been already said in our *Contemplation of the Muscles*, since it was impossible to treat of these last with any manner of Clearness, without some knowledge of the former, to which therefore, if any one thinks it necessary, he may have recourse.

Sect. VIII. *The Thigh-Bone.*

Let then a Philosopher that is enquiring after Truth, take into his Hands such a Thigh-Bone as we have described (*Tab.* IX. *Fig.* 3.) A E, and such as he may have met with many times in Church-Yards and Charnel-Houses, without taking any notice thereof, and he may see in this alone, the Great Creator's wonderful Direction to so many necessary Uses. For he will find, *first*, that the same is very hard and stiff, to enable it to bear the Body; but at the same time hollow, that it may not incumber the Motion thereof by its Weight; and at the same time to be provided with a Marrow, that is so necessary, and to keep it ready for the Service which it is to perform; of which hereafter.

Secondly, That in *Tab.* IX. *Fig.* 4. the Knob or Head of the Bone A is round, and is so accurately adapted to the *Os Ischii*, or Hip-Bone B, that it can turn round therein, and be moved on all sides.

Thirdly, To give some slight Description of this Joint, since the Figure will help us therein; can we discover no Wisdom in the following Particulars? *viz.* *First*, this Head A, is surrounded with a kind of a smooth polished Cartilage, to the end that it may perform its Motion without Resistance and without Pain. *Secondly*, That to give the greater Steadiness to the Joint, this round

Bone A, is fastened in the Cavity, as it were with a Rope or Tendon, by a Strong-band *b*, which however does not obstruct its Motion. And *Lastly*, that a broad Band, *a*, surrounding the whole Joint (but which in this Figure is represented as cut through) ties the whole together, still preserving the Freedom of Motion.

Fourthly, To proceed in the Contemplation of the aforesaid Thigh-Bone (*Tab.* IX. *Fig.* 3.) it has two Eminences, or Heads, D D, at the place where it makes a Joint with the Leg or Shin-Bone below at the Knee; which are both likewise encompassed with Cartilages, that they may slip the more conveniently and smoothly. These two Heads, D D, (or *b b*, in *Tab.* IX. *Fig.* 5.) have between them a pretty deep Hollow or Groove *e*, and are both adapted to two Cavities *c c*, which are above in the Shin-Bone K; and that again has an Eminence lying between the two Holes *c c*, which is likewise adapted, and enters into the internal Angle *e*, between the Heads of the Thigh-Bone *b b*. Now, need we say any more to prove very evidently the Designs of the Divine Architect? And he, who in any wise comprehends it, must he not be convinced that this Joint is of a different Structure than that of the Thigh-Bone; and that it ought to be so, forasmuch as the Knee is only to be bent forwards and backwards, but by no means sideways, as the Thigh-Bone, and that otherwise it would produce a very irregular Gate.

Fifthly, To say nothing of the Ligaments or Bands, which (like as in the Joint of the Thigh with the Hip-bone) preserves all this from disjointing: Nor likewise of the Knee-pan, the Use of which is best known to them who having broken the same by any Mischance, are thereby deprived of the chiefest Strength of this Joint.

Could any one see that the little round Bodies B and C (*Tab.* IX. *Fig.* 3.) are of so great use for the Insertion of the Tendons of Principal Muscles, and still suppose that this Bone had acquired its Form without Design? In which, not one Eminence, not one internal Angle is to be found, which, if it had been of a different Structure, would not have occasioned remarkable Inconveniencies to Men.

If any Body would see the manner of such a Structure at his Ease, he need only consider the Claw and Leg of a *Pullet*, and that to which it is fastened at both Ends, where he will find something very analogous to what we have now described.

Sect. IX. *The Teeth.*

To the abovementioned Account of Bones, we might have added the particular Properties of those whereof the Teeth are compounded, and how they differ from other Bones, to the end they may be the better adapted to their own Uses. Now in case they had been produced by Chance, or by Causes operating without Understanding, why are these Bones exactly provided with the different Qualities which they themselves required? And why do they so seldom appear in the Mouths of Young Children in the first Months, when they would be both inconvenient to the Sucking Child, and Painful to the Mother? And why are they produced at the time, when the Stomachs of those Young Creatures are capable of digesting more solid Food? Those

Those who desire to be informed of other Circumstances about the Teeth, may consult what has been said above touching the Mouth, Chewing, *&c.*

Sect. X. *The Bones in unborn Children.*

The Diligence of Anatomists has discover'd many things in the Bones of Children before their Birth; and plainly shewn in several Cases the difference there is between those of a new Born, and of a Person in Years; yet it is still unknown of what Matter they are composed at the Beginning, and afterwards in their Changes, till they have acquired their Solidity and true Nature; and particularly, what were the real Causes of the whole.

So that no Body who believes the Divine Origin of the Holy Scriptures will be surprised, that the adoreable Spirit of God, with which the Writers thereof were endowed, has been pleased to make use of this Instance, to prove the Smallness and Narrowness of our Knowledge in these Matters, by the following Expressions, *Eccles.* xi. 5. *As thou knowest not what is the way of the Spirit, nor how the Bones do grow in the Womb of her that is with Child: even so thou knowest not the Works of GOD who maketh all.*

The Enquiries of the accurate *Malphigi*, where he treats of the wonderful Formation of the Bones of a Chicken in the Egg, are worthy to be consulted upon this Occasion; but without going so far, the few Observations that we have yet been able to make in the Bodies of Men, do confirm experimentally, and plainly enough, these Words of *Solomon*; when we see the Great *Harvey*, who is so justly esteemed throughout the World, on account of his famous Discoveries, thus speaking in his Treatise, *de Ord. Part. in Generat. In the first Months some of the Bones are soft, others cartilaginous; the Arms so short, that when laid upon the Breast, the Fingers cannot touch each other; nor can the Legs, though folded upon the Belly, scarce reach to the Navel: And this comes from hence, that the whole Fruit has hardly the length of the Nail of ones Finger, till it comes to be about as big as a Frog or a Mouse.*

At first, *there are formed little Fibres, or Threads, of the consistency of Slime, which are afterwards nervous, then cartilaginous, and finally of the hardness of a Bone. In the second Month* (according to the several Experiments of the abovementioned Author) *the Embrio is very big in its Head, and very short in its Legs; and the whole Matter so soft and inconsistent, that it can hardly bear touching with the Hands; and in order to be examined, must be laid in Water; nor is there any Solidity in the Bones.*

Sect. XI. *The Bones are produced from a fluid Matter.*

Before we proceed farther, let the Reader consider with himself, whether it can be thought that an Over-ruling Power and Providence had no share in this Matter, when he sees hard Bones so wonderfully adapted to many Uses, arising only from a slimy Matter, which owed its beginning to nothing but Bread and Water?

For that the Bones, be they never so hard, do in a great manner arise out of a Fluid, is abundantly proved by the Chymists, who having distilled the same quite dry, and without the addition of any Liquid Matter, do produce from thence a great Quantity of Oyl, and yet more of Watry Parts (in which their Volatile Salt is melted, and which therefore is called their *Spirit*) as is well known to such as have made the Experiment.

SECT. XII. *Psalm* CIX. *ver.* 18.

NOW with how precise a Knowledge the Holy Ghost has spoken in other Places of Scripture, even of this internal Structure of the Bones, will appear as plain as the Sun at Noon, to such as, from Chirurgical Experiments, have learnt, that there is nothing more pernicious to a naked Bone, than to put Oyl, or any other Moisture upon it, which will cause a miserable Corruption therein: On which account it is, that the most skilful Surgeons, in treating about the Diseases of the Bones, do most carefully warn the Readers against the same.

For an Instance hereof, one need only read the Words of *Hildanus*; *Ab omnibus autem humidis & oleaginosis in denudatis ossibus in quacunque corporis parte, plané ut abstineat Chirurgus necesse est. P.* 816. *That is to say, a Surgeon must carefully abstain from the use of all moist and oily Matters in the managing of naked Bones, in whatever Part of the Body they lie.* As also Mr. *Paré* says, upon the same Occasion, *p.* 560. *Moreover, the Bones may be likewise corrupted by the improper Application of any Oyls, or other moist Medicines.*

I have only produced the Evidence of these two Gentlemen here, because they may be justly ranked among the most Famous and Skilful Men in this Art.

For to return to the Matter again; Can any one that reads that Text in *Ps.* cix. *ver.* 18. *As he cloathed himself with Cursing, like as with his Garment: so let it come into his Bowels as Water, and like Oyl into his Bones*; and who has ever seen this *Caries Ossium*, or Corruption of the Bones, in any considerable degree in a living Person, and has been informed that the same may be produced, or at least augmented, by any Liquid or Oleaginous Matters, must needs confess, that the Wrath and Curse of GOD cannot be described by more lively Comparisons, since Water and Oyl, that are mentioned in this Text, are both of 'em the most pernicious things imaginable to the Bones?

SECT. XIII. *Bones without Nerves.*

ACCORDING to the very Learned Anatomist, Mr. *Verheyen*, the Bones having no feeling, are consequently without Nerves, which are accounted by all for the Instruments of Sensation; but whether that be produced by their *Marrow*, *Juice*, or *Membranes*, we shall not here contend: The same is not obscurely maintained by a famous *English* Anatomist, Dr. *Clopton Havers*, who, though he differs a little from the former, touching the feeling of the Bones, yet, in his *Osteologia Nova*, or *New Descriptions of Bones*, p. 29. he affirms, that having enquired as nicely as possible into this Matter, he could discover no Nerves in the Bones, but endeavours to shew how this Absence of the Nerves may be supplied; so again, speaking of the Nerves of the Teeth, *p.* 102. he says, that *there be other Bones to which it should seem that no Nerves do belong.*

SECT. XIV. *Marrow.*

BEFORE we conclude these Remarks concerning the Bones, we must say a Word or two about the Marrow: Now can any one suppose that the Bones

were made hollow without Design, since they serve for the Receptacles of a fat or greasy Matter, which renders the Limbs smooth and supple in their Motions, and prevents the Cartilages in the Joints, when sliding upon each other, from being worn out or burnt by a continual Attrition, which wou'd happen if they shou'd remain dry, as appears in the Axel-trees of Waggons and Mills, which are greased for that very purpose.

Not to mention here, that by the said Grease or Marrow the Bones themselves (which being otherwise too dry, would become brittle) and the Ligaments or little Bands thereof are kept in their proper Condition by such a Moisture; as we see the Musicians oil the Strings of their Instruments, to the end that they may not break by too much Driness.

How plainly then does the Wisdom of the Great Creator shine forth in this very Matter, by contriving in so hard a Substance as Bones are, Ducts and Passages thro' which the Marrow may ooze out or *filtrate* from the little Tubes of the Bones into the Joints?

SECT. XV. *Water and Oyl together serve to render the Parts smooth.*

THEY that deal with Air-Pumps (the Construction of which, to render the Matter more intelligible to unexperienced Persons, must be supposed to be like a great Syringe) know, that the Sucker thereof must be first steep'd into Water, to make it swell out to the necessary Thickness and Softness; after which it is oyled a little, that it may move backwards and forwards more smoothly and readily; from hence it is plain, that when the Sucker, tumified with Water, is thrust with some Force into the Tube of the Air-Pump, which is narrower than the extended Sucker, the Water is pressed out and mingles itself with the Oyl that was smeared over the Sucker.

Now could any Body, who has never made a Trial thereof, (to add something here which is very remarkable) imagine, that Water and Oyl thus mixed together, are much more proper than Oyl alone, to cause two Bodies, rubbing against each other, to move more smoothly and nimbly upon one another? And yet, that this is true, the aforesaid Experiment has taught us; wherefore, it is likewise very useful, that the Sucker, already smeared with Oyl, should be even once again dipt in Water, before it be thrust into the Tube of the Air-Pump.

The first Observer hereof, was the great Mr. *Robert Boyle*, who, upon the account of his Enquiries into the Creatures, can never be sufficiently praised: That Gentleman, in the Introduction to his *Physico-Mechanical Experiments*, p. 7. *of the Cologn Edit.* speaks thus of this Mixture of Water and Oyl, to render the Motion of his Air-Pump more easy, *Upon which Occasion we must not here omit (because it appears so wonderful) that neither Oyl nor Water used singly, could bring to pass that the Sucker should be moved easily and readily; but that a Mixture of them both (several times repeated to our great Surprise) did produce the desired Effect.*

Thus we see that a Gentleman, who, if he can't be called the greatest Philosopher in the World, yet may justly be placed in the first Class of Great Men, acknowledges himself, that he could never have discover'd this by Argumentation,

gumentation, but learnt it (*to his great Surprize*, which ought to be well observed here) by Experience only.

SECT. XVI. *Oyl and Water thus mingled, insinuate themselves into the Joints.*

NOW let the Atheist, that has never so high an Opinion of his own Understanding, or the strongest Mind (as they love to call themselves) seriously consider by himself, laying aside all Obstinacy and Passion, whether he can attribute all this, with the least appearance of Reason, to *meer Chance*, or *ignorant Causes*; when he sees with his own Eyes, that in order to render the Joints more supple and moveable, and to produce such a mixture of Oyl and Water as would be fit for that purpose, there are found, in and near the said Joints, perpetual Springs and Fountains; out of some of which there flows a kind of Oyl of the Marrow, (of which Mention has been made above) and from others a tough slimy Humour (which the said Dr. *Clopton Havers*, the Discover thereof, calls the *Mucilago*) into the Joints, between the two Cartilages that rub upon each other. And the said Author shews by Experience, that it is not without just Cause that he names them watry Humours, because he proves, that after the Evaporation of the Water, there does hardly remain the thirtieth Part of that Matter.

Once again, I say, let such an unhappy Infidel betake himself to some Retirement, where he need not be affected with the Shame of recanting those erroneous Opinions, which he has so long and so boldly maintained, and consider, whether he can believe, since this mucilaginous and watry Humour is of so great Service, that all this *Apparatus* of so many Glands as are found in the Joints, and which being compressed by the Motion of the Bones, do, like squeez'd Sponges, yield this Moisture; I say, whether such a Disposition can be made without any determinate End: And, on the contrary, whether he does not plainly discover therein, the Wisdom and Designs of the Creator.

As *first*, that these Glands (some of which being taken out of the Joint of the Elbow, are of the Form represented in *Tab.* IX. *Fig.* 6. and others lying by the Knee-pan C, taken out of the Knee at *a a a*, *Fig.* 7. with the Membrane *b b b b*) placed in such a manner, as not to receive any Prejudice by the pressing of the Bones; for which Purpose, the Great Creator has prepared for them a Cavity, which encompasses and secures them against any rubbing or breaking in great Motions and other Cases. *Secondly*, However in such a manner, that when there are great Inflections, and much Work to be done by the Joints, they may be softly compressed, to make them yield their Liquor more freely, of which a greater Quantity is then wanted; and when the Joints are at rest, these Glands may preserve more of it in them, and not shed it in vain. Those who desire a more exact Account hereof, founded upon several Experimental Discoveries, may have recourse to the above-mention'd Treatise from *pag.* 227, to *p.* 232.

SECT. XVII. *Convictions from the foregoing Observations.*

NOW how many Convictions of the Wisdom and Goodness of GOD may be deduced from this Description of the Marrow and Structure of the Glands,

may be learned from the aforsaid Author, *pag.* 238. whose Words are as follows: *And here we cannot forbear to observe the visible and palpable Tokens and Footsteps of an Infinite Reason, which, as they are deeply engraven upon the Universe in general, are yet so in a much more particular manner in this wise Disposition of Motion in Animals. Nor can we ever sufficiently admire the Wisdom and Providence of our Great Creator, who has communicated to all the Parts of these Beings, not only such a Composition, by which all the necessary Motions and Operations, requisite in them, are conveniently produced; but has moreover endowed them with such Advantages and Privileges, whereby they can both support themselves, and discharge their proper Functions in the most easy manner.*

CONTEMPLATION XII.

Of the Sight.

Sect. I. *Transition to the Sight.*

WE proceed now to the External Senses, and among them to observe in the first Place the Instruments of Sight; where it must needs appear incredible to every one, that such a Number of Particulars and Circumstances as are requisite in so great a Matter as that of the Sight, should have concurred and met each other in so small a Compass as the Space that contains the Eye, by meer Chance, or necessary Causes, without the least View or Intention of the Creator.

To give therefore a Brief Account of the External Disposition of the Eye: Can it be thought to happen without Design?

Sect. II. *The External Structure of the Eye.*

1. That because the Eye is so tender as to be hurt by the least Accident whatever, the Eye-lid may, like a Curtain, be drawn over it with unconceivable Swiftness upon the approach of any Danger, for the Security thereof; and at the time of Sleep, to hinder the Operation of Light upon it to the breaking of that Rest which is so necessary to it. And again, that with the same Swiftness for the Admission of Light, the Eye-lid can be lifted up and folded together, for which End it is provided with particular Muscles.

2. To the End, that the Eye-lids may not hang loose and flabby upon the Eyes, and that their Motion may be the swifter, they are provided with a Cartilaginous Bow, which is accurately and nicely adapted to the Convexity of the Eye.

3. That the Eye is encompassed on all sides by Bones, to defend it from all outward Harms: Forasmuch as by the least pressure the Figure of it would be changed, and (not to mention the Pain or Smart) the Sight would be greatly dis-

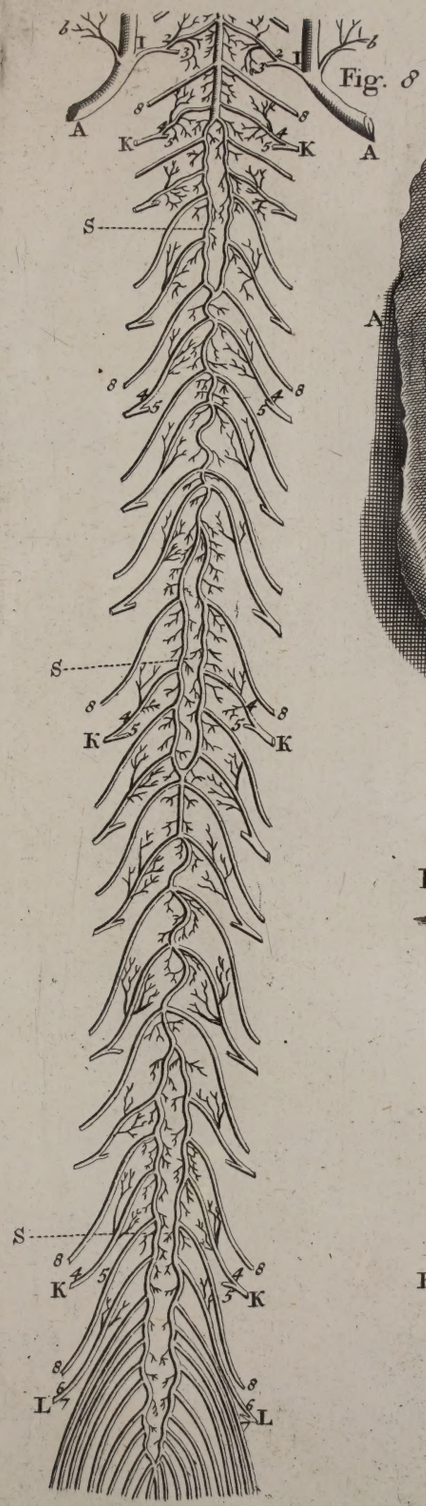
Fig. 8
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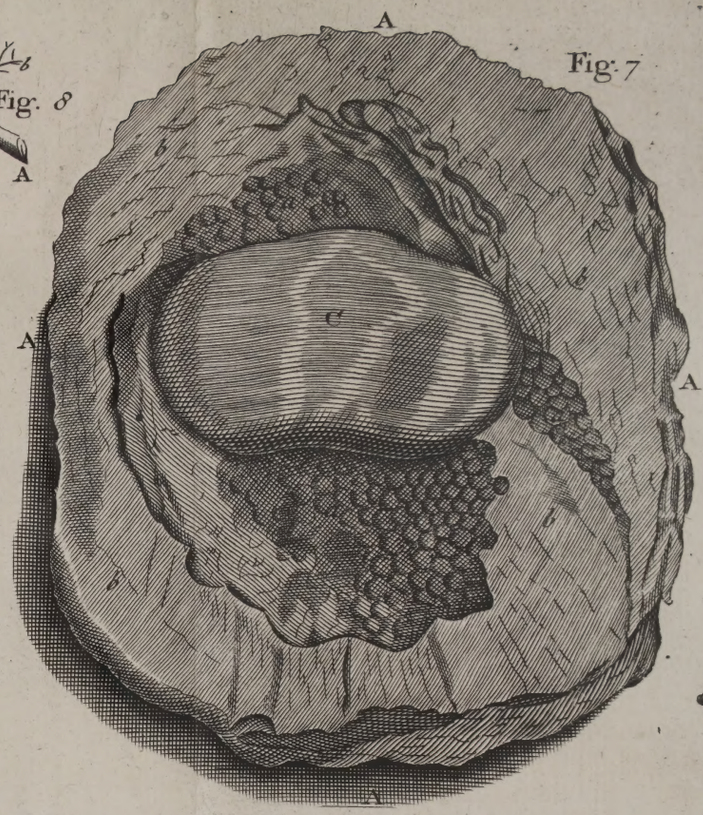
Fig. 7
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Fig. 1
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B
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Fig. 6

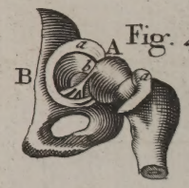
Fig. 4
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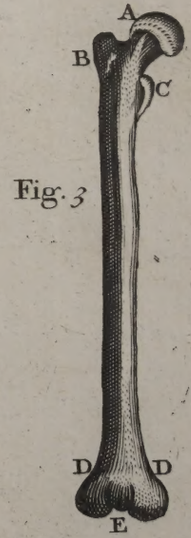
Fig. 3
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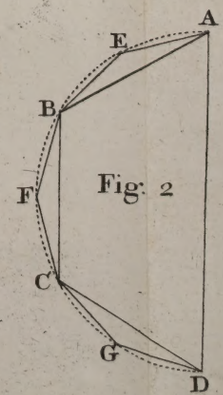
Fig. 2
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D

Fig. 5
K

diſorder'd. If any body doubts of this, let a Man ſhut one of his Eyes, and preſs the other gently with his Finger, and he will preſently be convicted of this Truth by the different Appearance of viſible Objects.

4. The Structure of the Eyebrows, which are provided with Hair, to prevent the deſcending Sweat of the Forehead from running into the Eyes.

5. To the end that the external Membrane of the Eyes may not be dryed up, and wrinkled by the Air, and ſo not only the Motions of the Eye-lids, but likewiſe the Sight itſelf obſtructed; that there are Glands placed in one Corner of the Eye, and over it, which by ſeveral little Tubes, ſhed a continual Moiſture upon the Eye, to make it ſmooth, and to ſecure the Membranes from too great a Dryneſs.

6. And to the End, that the Countenance ſhould not always appear Weeping and cover'd with Tears, that there are Paſſages contrived, by which this Humour at the uſual Times can be diſcharged into the Noſtrils. And the ſame Humour in extraordinary Occaſions, being changed into a flood of Tears, we are then much more ſenſible of the Courſe of them into the Noſtrils.

7. To the end that we may not be obliged continually to turn the Head to different Objects; there are different Muſcles faſtened to the Eye, that in an inſtant of Time do ſuffice to turn it on all Sides.

8. That no part of this Muſcular Structure ſhould be in vain, the Eye is made in a manner Globular, to turn indifferently in a Cavity adapted to it; the back Part of which is lined with Fat, to render the Motion ſmoother and quicker.

Sect. III. *The Properties of Light.*

If all this be not ſufficient to convince the moſt obdurate Atheiſt, let him go on to contemplate with us that which follows, and we do not queſtion, but he will be forced to own, that the moſt ſecret Laws of Opticks and Mathematicks muſt have been known to him that formed the Eye, before He could have produced ſuch a wonderful Machine.

Now it will be neceſſary to ſhew ſome of the Properties of Light, to ſuch as are unexperienced in the aforeſaid Sciences; to the End, that they may have a tolerably clear Conception thereof. It is therefore well known,

1. That the Light either of the Sun or of a Candle K, (*Tab.* X. *Fig.* 1.) (to give an Example thereof) falling upon the extream Part or Point of a Needle, render the ſame viſible to an Eye at C, C, C, *&c.* and R, wherever it be. So that it appears from thence, that the Light diffuſes its Beams, P C, P C, *&c.* ſpherically, towards all ſides, or rather like a round Ball; and therefore, that in the whole upper Superficies of the ſaid Ball, as C, C, C, R, *&c.* no Point can be taken, to which ſome Ray, as P C, is not extended, ſuppoſing the Eye at any of the Points, C, C, C, *&c.* or where-ever elſe it is placed in that Sphere.

And that this is each time performed in a ſtrait Line, may be obſerved from hence; that a dark Body S, placed between the Eye at R, and the Point P, in the Right Line P R, hinders the Eye from ſeeing the ſaid Point P.

2. This continual Scattering or Separation of the Rays, P C, P C, *&c.* from each other, is called *Diverging*: And thus we ſee, that all the Rays of Light P C, P C, *&c.* with reſpect to one another, when they proceed from the ſaid

Point

Point P, are what the Learned call *Divergent*; as on the contrary, thoſe Rays, for inſtance, that flow from ſeveral Points, C C, *&c.* and by the help of Burning-Glaſſes, or other Optical Methods, are compelled to run into a Point P, are called *Convergent.*

3. It follows from this Divergency (*Tab.* X. *Fig.* 3.) that if from all the Points, as A, N, L, M, B, of the Line A B, (or rather from ſo many as there may be in the whole Line A B) the Rays fall upon another Line S T; that the Rays flowing from all the Points of A B, to each and ſingular Point of the Line S T, cannot be extended without an apparently great Confuſion.

4. Wherefore, in caſe the Rays *Diverging* after this manner, ſhould fall directly upon that Part of the Eye where the Sight is to be formed, the Rays proceeding from each Point of the viſible Object A B, would ſufficiently fill the whole Superficies of the Place, and fall into great Confuſion among one another, as may be ſeen at S, T, O.

5. Now 'tis a known Law of Opticks, that in order to ſee an Object diſtinctly, all the Rays coming from a Point thereof (as from B for inſtance) muſt be collected at the Bottom of the Eye in a Point *b* (and ſo ſuch as come from A, and other Points of the ſaid Object, in ſo many other Points again, as *a*, *&c.*) thus forming upon the Bottom of the Eye at *a b*, the Picture or Image of the Object A B; but inverted, or upſide down.

6. Now ſince this cannot happen unleſs the Rays, which, according to the Natural Courſe of Light, proceed from the Point B *divergently*, or wider from each other, are again made *Convergent* at the Point *b*, it has pleaſed the Great Creator to determine the Motion of Light, with reſpect to the *Medium*, or Matter thro' which it paſſes, by other Laws, by which He brings this great End to paſs.

Sect. VI. *Concerning Refraction or Breaking of the Rays.*

These Laws are thoſe which in Opticks are known by the Name of *Refraction* (that is the *breaking*, or rather the bending of the Rays of Light) and the Appearances thereof are as follows:

1. When Rays paſs from one Medium or Tranſparent Matter, ſuch as the Air, for inſtance, into another, as Water, Glaſs, Chryſtal and the like, whether it be denſer or rarer.

2. When they fall upon the latter with any Obliquity; for if they fall at Right Angles, or Perpendicularly, we find they paſs directly through, and are not broken, or bent at all.

Sect. V. *An Experiment of Rays paſſing from Air into Water.*

If you deſire to ſee this expetimentally, ſet a Candle in a dark Room (*Tab.* X. *Fig.* 2.) upon a Table, and an empty white Baſon N K L M, at a little Diſtance from it, in ſuch a manner that the Shadow of the Brim M L, of this Baſon, may extend it ſelf from M to D; when it will appear, that the Ray A M D, which ſeparates the Shadow at D from the Light, is the laſt Ray that falls on the enlighten'd inward Part of the Baſon N B D.

Then

Then lay a shining piece of Money E (for instance a Shilling) just within the Shade, so that the Edge of it may approach very near to D; you must take care next to fix that piece of Money in such a manner, that it may not remove from its Place; and lastly, fill the Bason up to B C with Water; then you will find that the Shadow will not extend itself farther than to F, and the Shilling E will lye out of it in a perfect Light: So that now H F is the last Ray that separates the Light from the Shadow.

Now it is plain, that from A to F there can come no direct Ray A F, because it is stopt by the Bason at P.

And yet you see the Light proceeding from A to F.

From whence it follows, that as the Ray moved directly in the Air from A to H, instead of proceeding strait forwards to D, it is broken and bent, and makes an Angle A H F, at the Superficies of the Water H, and so runs from H to F.

And thus you have an Example, how a Ray A H, passing through a thinner Medium, such as Air, into a thicker, as Water, is *refracted* or broken; and in such a manner as to bend towards the Perpendicular Line G H Q, which makes a Right Angle upon the Superficies B C, where the different Mediums of Air and Water are separated from each other.

SECT. VI. *An Experiment of the Refraction of Rays passing from Water into Air.*

NOw to shew the Appearances of a Ray passing from a denser or thicker Medium, to a rarer or thinner, as from Water to Air:

Lay the said Shilling E, in an empty Vessel N K L M (*Tab.* X. *Fig.* 4.) so that one that stands at A S, may be just hinder'd by the Brim of the Vessel L M, from seeing the Money at E: Forasmuch as from E to the Eye A, no direct Ray A E can proceed, by reason of the Interposition of the said Brim M L.

Then fixing the piece of Money E, to the Bottom of the Vessel in such a manner, that it may not be removed by pouring in the Water, let there be Water poured into the Vessel as high as B C: Whereupon he that stood at A S, and could not see the Shilling before, will perceive it very clearly, as if it was at F.

Now it is plain from all this, that the Money really lay at E: and that it could not be seen by any direct Ray E A.

And yet it was clearly seen at F.

From whence it follows, that it must have been seen by the Refraction, or bending of the Ray E H, which, instead of running directly to I, makes the Angle E H A, and so reaches the Eye A.

Which (because we are wont to imagine that we see nothing but what lies in a right Line, extended from our Eye to the Object) sees this piece of Money as if it lay at F.

And to prove that it only happens thus by the aforesaid Refraction, let another Person be placed at I O, whose Eye I, is not able to see the Money E, while it lies in the empty Vessel, the Brim of which, N K, intercepts the direct Ray I E; and yet when the Water is poured into it, he will see the same lying at P, by the help of the Ray E R I, refracted at R: So that the

the ſaid Money will appear to the Eye A, removed from E to F, but to the Eye I, removed from E to P; and thus two contrary Motions will be produced: And in like manner, if there were a whole Ring of Spectators about the Veſſel, each one would ſee the Object in a different Place.

From hence it appears, that a Ray, E H, is refracted in paſſing from a denſer Body, as from Water, into a rarer, as Air; and that it does not run directly from H to T, but to A, and ſo is ſomewhat inflected from the Perpendicular Line G H Q.

SECT. VII. *An Experiment, ſhewing that Rays falling at Right Angles are not Refracted.*

IT is likewiſe plain, that a Ray falling perpendicularly from one tranſparent Medium to another, ſuffers no Refraction, (as the afore-mention'd Ray did, which came upon it obliquely) if you look upon the aforeſaid piece of Money E, lying in an empty Veſſel, thro' a narrow and perpendicular Tube D U, whilſt it lies directly under it; after which, fill the ſaid Veſſel with Water up to B C, taking care that the Money remain in the ſame Place, and the Tube in the ſaid Poſition, thro' which the Money will be ſeen juſt as it was before: Whereas, if you look at it thro' the Tube lying obliquely in the Poſition H T, the Money will not be ſeen at E, as in the empty Veſſel; foraſmuch as, in order to ſee it again after the Water is poured in, the Tube muſt be brought down from H T to H A, by reaſon of the Refraction of the Rays: This is what every one may try, as well as we.

SECT. VIII. *Divergent Rays made Convergent, and forming an inverted Image.*

FROM theſe two Laws there does not follow a General Rule, which, as appears by innumerable Experiments, is always obſervable in the Motion of the Light, *viz.* that (*Tab.* XI. *Fig.* 1.) the Rays B H, B H, *Diverging* from a Point B, may, by Refraction, be inflected towards each other, and become again *Convergent* in a Point *b*.

1. When they paſs from a rarer Body into a denſer, which is Convex and Spherical; and, 2. When they fall upon an Object of the like Figure, from a thicker to a thinner Medium.

For inſtance, let K F be a Glaſs poliſh'd on both ſides, and each ſide of K M F and K N F be Convex and Spherical: Now when the Ray B H comes upon it from the Air, it will not proceed to R, but be inflected towards the Perpendicular G H, and take its way according to H P; but in paſſing from the ſaid Glaſs P, into the Air, it will not proceed to S, according to H P; but receding from the Perpendicular Line P Q, purſue its way to *b*.

And this happening to all the Rays, which fall from B upon the Glaſs between H H, they will all be united again about the ſame Place at *b*, only the middle Ray B M N *b*, becauſe it falls every time perpendicularly upon the Glaſs, runs directly forward, and without being refracted.

So that in caſe we ſuppoſe (*Tab.* X. *Fig.* 3.) that at S T, a Glaſs is ſo placed, as that the Rays paſſing from A to *a*, from B to *b*, and from the other Points,

Points, N, L, M, to *n, l, m,* be united together, they will make at *b a* an inverted Image of the Object A B.

Sect. IX. *An Experiment shewing the same.*

Let those who have a mind to see a very easy Experiment hereof, place one single Candle in a Chamber at Night, and retiring some Distance from it, let them cause its Light to pass thro' a Spectacle-Glass upon a white Paper: Whereupon, having likewise settled the Distance between the Glass and the Paper, they will see the exact Picture of a Candle inverted upon the said Paper.

That is, at the Place *b a,* where all the Rays coming from each of the Points of the Candle, at A B, are collected in so many other Points by the two Refractions, which (as in *Tab.* XI. *Fig.* 1.) they suffer thro' the Spectacle or Burning-Glass, convex on both sides, and so form the above-mention'd Image.

Sect. X. *A Second Experiment in a dark Chamber.*

There is another way of proving the same by the famous Experiment of a *dark Chamber,* which is made thus: You must make the Chamber as dark as you can, leaving a round Hole in a Window, something smaller than the Circumference of a Spectacle Glass; then place such a Glass exactly before the Hole, taking care that the Light has no other Passage into the Room.

Now if you hang a white Cloth or Paper at a proper Distance before the said Glass, so that the Rays that proceed from every Point of the Objects may each of them be collected into its correspondent Point, you will perceive that the Images of every thing that is without the Chamber will be painted in the most perfect manner upon the said Cloth or Paper, according to all its Lineaments and Colours, especially if the Sun happen to shine upon the external Objects, and the Glass be in the Shade; as it happens when, for instance, the Sun is in the South, and the Window in which the Glass is, stands towards the North, so that none of the Sun's Rays come directly upon it.

Sect. XI. *Convictions from the foregoing Observations.*

Now since it is the Property of Rays that proceed from a Point, to be diverged and scattered from each other, and that they must be made to converge, or be united in a Point again, in order to form the Picture of an Object, and thereby to make us see it distinctly: Can it be conceived that all these Laws concerning Light, all this Disposition made in the Eye (how small soever it may appear to an ignorant Person) and all the other necessary Circumstances observed therein; I say, can he believe that all these things have concurred in so little a Space, as that wherein the Eye is placed, without any Design or Wisdom of the Creator?

SECT. XII. *The Eye is a Dark Chamber.*

NOW to represent this Matter to every one's entire Satisfaction, and to convince him, that the Images of visible Objects are really painted upon the Bottom of the Eye by the Light, after the same manner as in the above-mention'd dark Chamber by a Convex Glass; he need only take (thus I find the Experiment to have been made in the Year 1696) the Eye of a newly killed Ox, while it is warm, (see *Tab.* XI. *Fig.* 2. CGRH) after having divested it of its Flesh and Fat, and left nothing remaining but the Membranes and Optick Nerve; then about *b* or *a*, behind in the Eye, let there be a small Hole made with the Point of a sharp Knife, in the Membrane in which it is involved; and moreover a little round piece, of about a Finger's breadth, cut out with fine pointed Scissors, leaving it fasten'd only at X, so that the Eye may be held by the Part here represented at X*t*, and so the Orifice CCN directed which way one pleases.

Then placing the Flame of one Candle only, lighted for that purpose, in a dark Room, before the Eye at A B, you shall see the exact Picture of the same inverted very plainly at *a b*, and represented burning upside down.

But that this Experiment may be made as it ought to be, care should be taken not to hurt a very fine and tender Membrane, including the vitreous Humour behind at *a b*: For whereas you otherwise see the said Humour itself transparent and naked, some Light may perhaps appear, but the Image will not be so well represented.

However, upon such an occasion, which easily happens, one may cover the naked vitreous Humour behind at *a b*, with a very fine white Paper; by which means you will see the exact Form and Motion of the Flame, and also the Top of the Candle itself, accurately drawn upon it.

It is more convenient to try the Experiment after this manner, than to place the Eye before the Hole of a dark Chamber, in order to admit thereby the Images of the external Objects: It is likewise performed this way with much less trouble.

For one may easily see this way, 1. That the Eye being brought nearer to the Candle, the Picture is drawn sensibly larger; and if removed farther from it, it becomes smaller again. 2. That upon moving the Candle towards the Right, or Left Hand, the Picture goes in a direct contrary Motion.

From whence it seems probable, that our Great Creator makes use of these Means, to the end, that by increasing or lessening the Images formed in the Eye, we may judge of the Distance of Objects by their apparent Greatness, or of their Greatness by their apparent Distance; as He likewise makes known to us the Motion of Things that are remote from us, by the Motion of their Images.

For that these Images are not formed in the Eye, without making some Impression upon the Membranes thereof, seems deducible from what a Man feels, who has been any time in the Dark, when he suddenly returns into a great Light, and opens his Eyes to look about him.

SECT.

Sect. XIII. *No Images by Divergent Rays.*

Having thus far shewn that our Eye is a real dark Chamber, this Truth does likewise occur to us, namely, that such Images of an Object AB, cannot be formed upon the Bottom of the Eye at *ab*, by Rays, which, for instance, flow from the Point B, so long as they are Divergent, as at BC, BC; but that it is absolutely necessary for that purpose, that they should be bent again towards each other by Refraction, in order to be collected into a Point *b*, and there to form the Image.

Sect. XIV. *The Transparency of the* Tunica Cornea.

Now to represent only some few of those Circumstances, which may serve for Conviction, without embarassing a Reader not well skilled in Anatomy with the different Number of Names given by the Learned to the Membranes of the Eye, of which some Anatomists reckon only three others 4, 5, 6, 7, yea, 8 and 9, as you may see in *Verheyen*; Let us suppose the little globular Body, GCHR (*Tab.* XI. *Fig.* 2.) to be the Eye.

Now no Body will contest with us,

First, That in case all the Membranes which encompass the Eye were opaque as well as those that are in the other Parts of the Body; by reason of their want of Transparency, the Light would be able to get little or no access to the Eye.

Can it be then supposed to be without Design, that notwithstanding that the whole Eye is encompassed round about with an untransparent Membrane, GRH (which shews itself likewise externally, as the *White* of the Eye) yet, at that place where the Light falls upon it, at NCC, there should be found a spherical, thin, bright, and very transparent Membrane, such as the clearest Horn or Glass is, in order to afford a Passage to the Light; and which is therefore called the *Tunica Cornea*, or Horny Membrane?

Sect. XV. *The Aqueous Humour.*

Secondly, Now in case the Rays of Light, BC, BC, coming out of the Air, and from the Point B (for example) and having passed thro' this Membrane GNCH, should again meet with the same Air placed in the Cavity of the Eye, GSDTHCG; as it happens in the Cavities of the Ear, where such Air is necessary, they would proceed to diverge or separate themselves from each other, and so be unable to form an Image at *b*, which is requisite in order to see the Point B distinctly: Will any one again pretend, that it is without Wisdom and Design, that this Space GSDTHCG is filled with a Liquor that has all the necessary Qualifications in it, *viz.* that it is, *First*, entirely Clear and Transparent for the Reception of *Vision*. *Secondly*, that it is thicker than Air, and about the Substance of Water; for which reason 'tis called the *Aqueous or Watry Humour*. *Thirdly*, that it is convexly round, as appears by the external Figure of the Eye. From whence it appears plain, that both the Rays, BC, BC, divergent from B, cannot proceed forwards to *gg*; but by the Laws of Refraction, must be inflected towards each other, and pursue their way to DD, according to the Lines CD, CD?

Sect. XVI. *The Crystalline Humour.*

Thirdly, Now if we should suppose that these Rays, according to CD, CD, should again proceed directly to *d d*, we should at the same time find that they would either not at all run into a Point, or at least into such a one as lies very far behind the Eye.

From whence it follows, that there must be a new Refraction to inflect them again towards each other, in order to make them meet at *b*, or in a much nearer Point.

Now, in order to make this happen very exactly, another Body, SDTES, is necessary; which is, *first*, Transparent, *secondly*, Thicker than the Aqueous Humour, and, *thirdly*, in some measure Convex.

And here again we find all these required Circumstances to come to pass in such a manner; for the very opening of an Eye, may convince every Body, that the last mentioned Humour SDTES, is not only clear, but likewise of a thicker Substance than the *Aqueous*, for which reason 'tis called the *Crystalline*, and represents rather a solid Body than a fluid, and, which is yet more, it is Convex at SDDT.

These are therefore the Means that hinder the Rays proceeding, as CD, CD, from passing on directly to *d d*, and force them, according to the Laws of Refraction, to inflect themselves a second time towards each other, and to take their way to DE, DE.

Sect. XVII. *The Vitreous Humour.*

Fourthly, Again, if these Rays had pursued their Course strait forwards to *e e*, they would indeed have met again at the Point *k*, but that would have been too far behind the Eye; and they falling upon the Bottom of the Eye, would have taken up too much room at *m n*; and the single Point of the Object B, would have been here represented with a great Superficies, *m n*, which happening thus thro' all the Points of the Object AB, the Rays of several different Points lying near each other, would have struck the Bottom of the Eye in the same place, and so have produced a confused Image, and therefore confused Vision.

He that does not conceive this easily, may represent to himself, first, with a proper Exactness by the help of a Convex Glass, placed at ST, in a dark Chamber (*Tab.* X. *Fig.* 3.) the Picture *a b*, of an Object AB upon a white Paper *r s*; and then removing the Paper from *r s* to *p q* nearer to the Glass ST, he will perceive the Confusion of the Picture, for the Reasons that have been just alledged.

Therefore to prevent this in the Eye (*Tab.* XI. *Fig.* 2.) it was necessary, that a second Refraction should be made, whereby the Rays might be collect- at the Point *b*, instead of the Point *k*.

That this may happen after the best and most commodious Manner, the *Crystalline Humour* ST, must be again Convex at SET, and that which follows at SGRHTES, thinner of Matter, and likewise transparent.

Now

Now all these Particulars do occur here again; since the *Chrystalline Humour* (as you may observe, if you take it out of the Eye) is not only a Convex behind at S E E T, but much more so than in the Fore-part of it S D D T; the whole Cavity also of the Eye S G R H T E S, behind the *Chrystalline* Humour S T, is quite full of a very clear and bright Humour, about the Consistence of melted Glass, or, according to others, of the White of an Egg; at least, it is of a thinner Substance (which is necessary here) than the *Chrystalline* Humour, and therefore 'tis called the *Vitreous Humour*. This being so, they that understand the foregoing, must likewise know that the Rays coming from D E, can't pass directly thro' *e* to *k*; but being again broken at E, must be bent towards each other, and pursuing their way according to E *b*, E *b*, must be united at *b*.

SECT. XVIII. *How the Image is formed in the Eye, and Convictions from the foregoing Observations.*

Fifthly, HAVING thus shewn, how the Rays diverging from the Point B of the Object A B, must meet at the Bottom of the Eye in a Point *b*; if you suppose that those Rays which come from every other Point of A B, are likewise after the same manner collected in a visible Point of *a b*, you will also see after what manner the abovementioned Images are formed by the Light, upon the bottom of the Eye, as it were in a dark Chamber.

Now can any thing more be required by those who sincerely search after Truth, towards a Proof of the Wisdom of the Creator, than this wonderful Structure of the Eye, and these Inflections of the Rays repeated three times after one another; which, if they had been otherwise scatter'd or separated, would not only have been unfit in their own Nature, by reason of such Divergency, to have formed an exact Image, but even produced a Motion which would have been directly opposite to what the *Sight* required?

SECT. XIX. *Several Remarks; First, that the Eye is Black within.*

WE might make innumerable Observations upon the wonderful things that are to be found in the Eye; as, 1. That the Eye must be dark within, in order to represent the Images as strongly as is done in a dark Chamber, and is it not so? even so far, that its Membranes or Tunicks, are in a great measure, and for this very purpose, of a Blackish Colour: Can so necessary a Quality as this result from Chance?

SECT. XX. *The Second Remark; That the Crystalline Humour is a Microscope: And Convictions from thence.*

2. TO the end that the Images should be nice and accurate, ought there not to be in the Eye a transparent Body, Convex on both sides, and the most Convex part undermost? And do not both these Qualities occur in the *Crystalline* Humour, which has the form of a polished spherical Glass before and behind, as likewise all its Properties?

For, if you take this Humour out of the Eye of a newly killed Beast, and hold it before a burning Candle, and a piece of white Paper behind it,

you

you will see upon the Paper as exact an Image of the Flame inverted, as if the same were projected or made by a Glass: Or place the same before your Eye, and the Head of a Pin, or any other little thing, close behind it, and if you look thro' it, you will see the very same Appearances as thro' a real Microscope, which is likewise made Convex on both sides for the same purpose.

Did ever any one pretend to say, that a good Microscope had acquired its Figure, its Transparency out of a dark or opaque Matter, and its Disposition of being so useful, without any Design of the Person that made it? How therefore can it be asserted of this Humour, where all those Qualities are found in a more eminent manner? Or could the best Artificer in the World, produce such a thing from Bread, Flesh, Fish, and other Food? Can then an unhappy Philosopher discover neither Art nor Knowledge therein, after having observed the like Appearances, not once only (which might have happen'd by chance) but in so many Millions of Eyes, both of Men and Beasts?

SECT. XXI. *The Third Remark; Upon seeing at several Distances: An Experiment thereupon.*

3. ONE may yet farther see by the Experiment in a dark Chamber, that the Distance of the Object A B (*Tab.* X. *Fig.* 3.) from the Paper *r s*, and from the Glass S T, ought to be certain and limited to form a distinct Image at *a b*: So that the Paper being held at *p q*, nearer to the Glass S T, or at *d e*, farther from the said Glass, if the Object A B and the Glass S T remain in their place, the Image will be very confused; because the Rays coming from each of the Points A and B, are not collected in the Point *a* and *b*, but instead thereof, take up a great space at *p* and *q*, or *d* and *e*; so that those which proceed from different Points must thereby be mix'd together and confused.

From whence it appears, that no Images can be rightly and truly formed, when the Collection of the Rays that come from A or B, are made at *a* or *b*; the place of Collection *a b*, being either before the Paper, which is then at *d e*, or behind the Paper, when at *p q*.

Again, we likewise see if the Object A B is further from the Glass S T, or the Glass itself is rounder than at the time when a distinct Image was formed thro' both of them at *a b*, the exact Image will fall closer to the Glass, as for instance, at *p q*; and therefore the Paper must, for this reason, be brought forwards from *r s* to *p q*, and nearer to the Glass.

The contrary happens, if the Object A B be brought closer to the Glass S T, or if the said Glass be not so Convex as we at first supposed it; for then the exact Image will not be found, unless the Paper be removed backwards to *d e*, and the Distance thereof from the Glass rendered greater.

Now, notwithstanding that all these things come to pass in our Eyes, yet would our Sight, for all this great *Apparatus*, be of little use, and wholly imperfect, with respect to the Objects that are near us: So that, for instance, one who sees an Object distinctly at the Distance of a Yard, would not be able to distinguish the same, either at the Distance of half a Yard, or a Yard

and half, or any otherwise, farther or nearer, unless the means above-mention'd were used in the Chamber of our Eye, *viz.* either by making the Roundness of one of the Humours more or less Convex, or the Distance between the *Chrystalline* Humour, and the Bottom of the Eye (which supplies the place of the Paper) greater or smaller, according as the nearness or remoteness of the Object requires it.

If this should not be sufficiently intelligible to one that has not been versed in Optical Experiments, let him in a dark Chamber make use of a flatter or more convex Glass; or to speak in the Language of the Glass-Grinders, of younger or older Spectacles, and of a greater or smaller Distance of the Object; and Experience, after a little attention, will render the thing plain enough to him.

Now, to apply all this to the purpose; Can any one, without being astonish'd at the Wisdom and Goodness of his adorable Creator, observe that not only one of these Means (which was enough alone) but both together are found in the Eyes? For when an Object is far from the Eye, and therefore (*Tab.* XI. *Fig.* 2.) the Point *a* or *b* (where the Rays proceeding from a Point A or B converge, or are gather'd together) does not reach the Bottom of the Eye X *m*, but falls nearer to the *Crystalline* Humour S T; a confused Image, as has been said before, would thereby be formed at the Bottom of the Eye, but no distinct Vision; so, that to prevent the same, it is necessary that the Distance between the Bottom of the Eye X *m*, and the *Crystalline Humour* S T, should be smaller; or (if the Distance between them remain as it was) one of the Humours of the Eye should be render'd less Convex, to cause the Image to fall farther, *viz.* at *a b*.

Now we find that to bring both these things about together, the four Muscles of the Eye, E F G H (*Tab.* X. *Fig.* 5.) seem to be necessary to move the same (as any one of them is contracted, and so made shorter than the rest) upwards and downwards, and to the right and left; and when they act altogether they draw the fore-part of the Eye, as likewise the *Crystalline* Humour, backwards, diminishing in such manner the distance between it and the Bottom of the Eye; but particularly, it is likewise plain, that they make the external Figure of the Eye, which is very Convex and Globular, much flatter, and so cause the collected Rays to fall more backward, in order to reach the Bottom of the Eye.

Now that the Rays coming from an Object, and falling upon a flatter Glass, do paint the Image further backwards than when the Glass is more Convex, has been already shewn in the Experiment of a dark Chamber.

Now if the Object (*Tab.* XI. *Fig.* 2.) be too near the Eye, and the Collection of the Rays coming from the Point B, does not happen upon *b*, but upon *k*, behind the Bottom of the Eye X *m*; it is plain enough, that to prevent it, the contrary must be effected, namely, that the Space between the *Crystalline* Humour and the Bottom of the Eye X *m*, should be made the greater; or (the Space remaining the same) the *Aqueous* Humour of the Eye, at M *c c*, somewhat rounder.

For

For that a rounder Glass forms the Image shorter and nearer to itself, may be experimentally proved with great ease in a dark Chamber.

Now to perform both these Operations at the same time, the Anatomists produce two Muscles at I N K M (*Tab.* X. *Fig.* 5.) which they call oblique Muscles; and which, when contracted, do each of them draw the Eye on its side; but when they work together, they draw the Eye as it were with a girting Rope, and swelling up, press it on all sides; by which means the *Aqueous* Humour being made protuberant, the Eye becomes rounder at N C C (*Tab.* XI. *Fig.* 2.) and the *Vitreous* Humour being pressed backwards, the Distance between the Bottom of the Eye and the *Crystalline* Humour is render'd greater.

I know very well that some Learned Gentlemen do not think that the peculiar Use of these Muscles, for this purpose, is yet fully ascertained, till it has been farther proved; but we shall not let ourselves into this Dispute at present, no more than we shall enquire whether those only have hit upon the Truth, who maintain, that the Fibres G S and H T (which the Anatomists call *Processus Ciliares*) have a quality of causing the *Crystalline* Humour it self (when ever it is necessary) either to change its Figure, that is to say, rendering it more or less Convex; or of bringing it nearer and removing it farther from the Bottom of the Eye.

However, the one or the other of the Operations above-mentioned, seems to be experimentally felt in the Uneasiness, or sometimes even in the Pain, which the Eye suffers, when we use any Force to see an Object that is far from the Eye distinctly, or to read a Writing a little too near.

But this is inconteſtibly true, that the Eye does something in the viewing of things that are placed at several Distances from it, without any Concurrence or Knowledge on our part, which the greatest Mathematicians have not yet been able to bring about by their Instruments of seeing; the Disposition of which, as the distance of an Object is notoriously greater or smaller, must likewise be alter'd. And this is sufficient to convince us (tho' we know nothing of the manner how it happens) that there is a God, by whom we are made, and who had a wise End and Design in forming the Eye, as it here appears.

Sect. XXII. *The Fourth Remark; Upon the Opening and Shutting the Black of the Eye, or Pupil, with an Experiment proving the same.*

Fourthly, If this great and wonderful Structure of the Eye, by which we are enabled to see so easily and distinctly, at so many and such different Distances, be not yet sufficient to convince a Sceptical Enquirer of the Wisdom of his Creator, let him proceed farther, and in the last place (since, if we take notice of every thing concerning the Eye, that alone would require a whole Book) to contemplate with us that which follows:

First, That if the Hole in a dark Chamber be made so small as to admit but too few of the Rays, the external Images would be represented imperfectly without the necessary Force and Liveliness.

Secondly,

Fig. 5

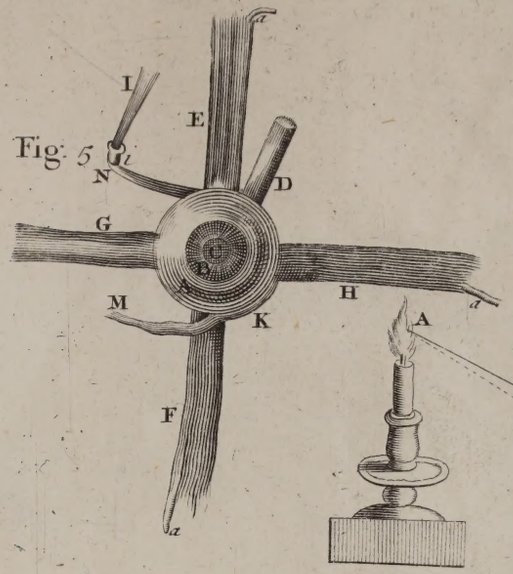


Fig. 1

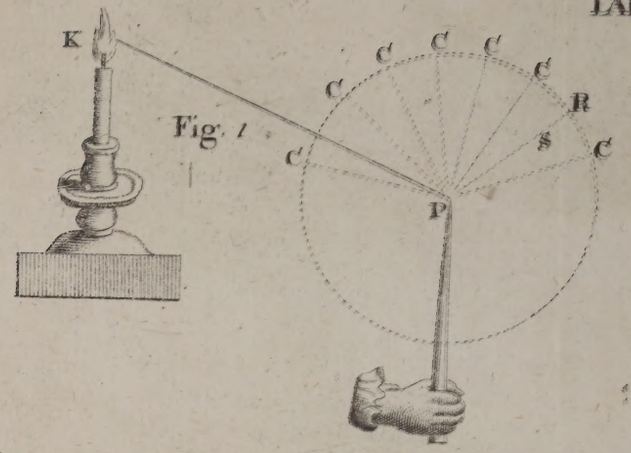


Fig. 2

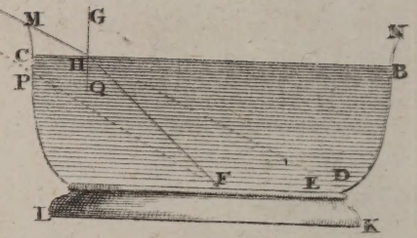


Fig. 3

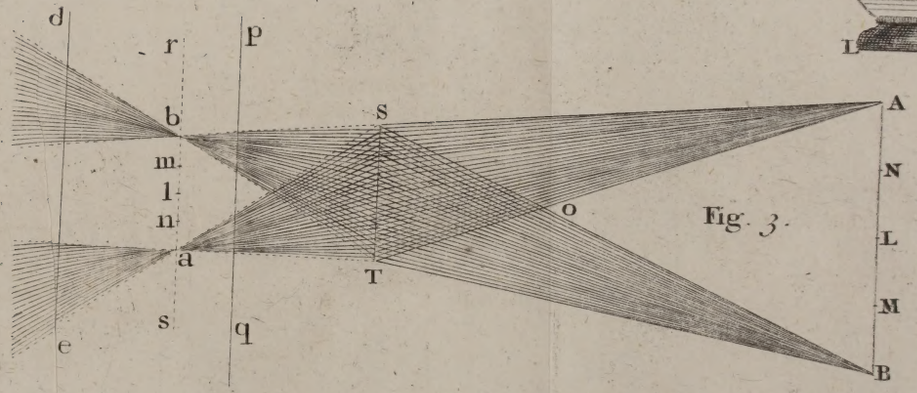
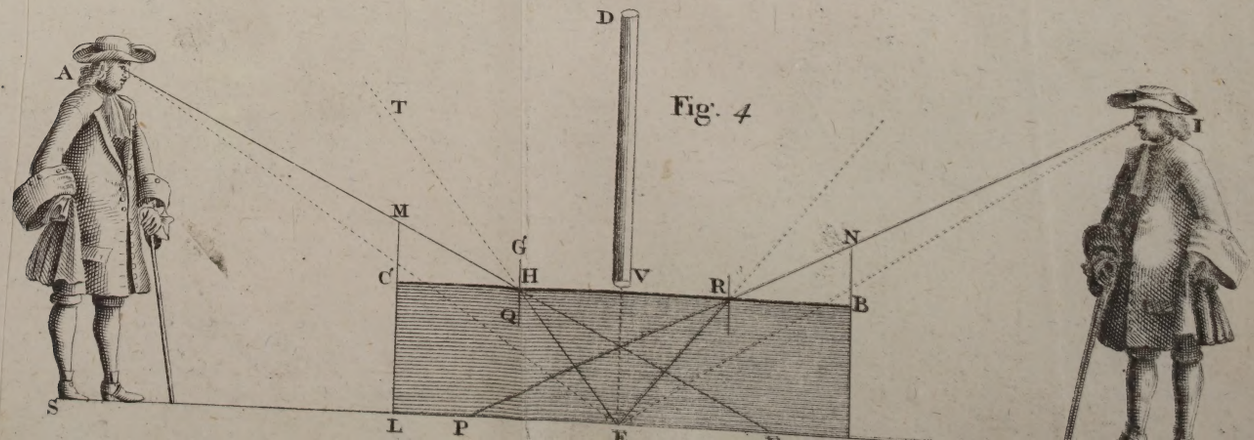


Fig. 4



Secondly, If the Hole be ſo great as to admit of the Entrance of too much Light, the Images would appear yet more weak and imperfect for other Reaſons. So that there is an exact Proportion required for that Hole or Space, thro' which the Rays are to be admitted, to the end, that every thing may have its proper Energy; and that the number of the Rays be neither too great nor too ſmall: And how much trouble the finding the juſt Proportion of ſuch Holes or Openings occaſions to thoſe who make Teleſcopes, Microſcopes, and other Inſtruments for ſeeing, is but too well known by thoſe that have had the trial of it.

The ſame thing happens to the Eye, as being a *dark Chamber*; and it is eaſie to diſcover experimentally, that too few Rays render the Sight of an Object weak, if you make a Hole with a Pin in a white Paper, which Hole ſhall be much ſmaller than the little black Circle of the Eye, called in *Latin*, the *Pupilla*; and thro' which the Rays of the Object are admitted into the Eye.

Now when you look thro' the ſaid little Hole (eſpecially in a place where the Light is not too ſtrong) upon a piece of Marbled Paper, in which there are a great many Colours, it is well known, that if it be held cloſe to the Eye, there can come no Rays from it but thro' the aforeſaid little Hole; and that therefore the number of them is much fewer than if they were immediately received in a greater Opening of the *Pupilla* without this Hole: But we ſhall likewiſe find at the ſame time, that the Colours of the Marble Paper will ſhew themſelves much fainter and darker thro' the little Hole, than they would directly to the naked Eye.

Now in caſe this Pupil, being too large, ſhould admit too many Rays, as it does when one paſſes ſuddenly from a very dark Place into a clear and ſtrong Light; we find likewiſe, that upon this account, the Action of *Seeing* becomes very troubleſome.

Now to produce again a Proof of God's wonderful Wiſdom and Mercy from this laſt Inſtance, could any Body reaſonably ſuppoſe, that what is done herein, with ſo much trouble by the Artificers in their Optical Inſtruments, is performed by the Eye of itſelf, and without the Direction of the Great Creator, and even without the Knowledge of the Man himſelf in whom it happens? And moreover, after ſuch a manner as infinitely exceeds the fineſt Machine that Human Art has ever yet brought to the higheſt degree of Perfection?

Thus we ſee that the Paſſage F F (*Tab.* XI. *Fig.* 2.) thro' which the Rays of Light go, or rather that black little Circle in the Membrane (according to which our Eyes are denominated Black, Grey, or any other Colour) commonly called the *Black or Apple of the Eye*, becomes in a healthy Man ſmaller in a great Light, and immediately greater in a ſmall Light; in order to admit more or fewer Rays, as the Circumſtances of things require.

I know very well, that no Body who has never ſeen this will readily believe it; but in order to convince him thereof experimentally, let him be brought into the Sun-ſhine, or any other ſtrong Light, or place him in a

Chamber directly opposite to the Light of the Windows in a very bright Day; where, if you observe the Pupil of the Eye, you will find it to be very small in such a great Light, to the end, that the Eye may not be hurt by the strength thereof; then set him in a dark Corner of a Chamber, and turn his Face from the Light; when you will presently perceive the *Pupil* to become sensibly larger, in order to admit a greater number of Rays; insomuch, that after these Experiments, no Body can doubt of what has been here said.

Is not the great Goodness of God particularly remarkable herein, that all these things come to pass in our Eye, without our being conscious thereof, to the end, that our Attention may not be diverted from whatever we are then contemplating? Which however would have always happen'd, if we had been obliged to have attended to every Occasion of adapting the *Pupil* to the Degrees of Light.

Sect. XXIII. *Convictions from the foregoing Observations.*

Now whosoever is a reasonable Person, and does plainly comprehend all that we have been saying about the Eye, ought he not to be astonish'd, that as there was a *Lucretius* among the Ancients, so there are likewise in our Age Men that pretend to be Philosophers and Enquirers after Truth, and yet will not allow that the Maker of all these things, which contribute towards the forming of a good Sight, had any wise Purposes or Designs in forming the same?

And yet if any of these Men should see a good *Microscope*, or a Sett of Magnifying-Glasses, or a well-made *Telescope*, or a *dark Chamber*, with all its *Apparatus*, none of 'em will dare to say that those things were framed by Chance. And can they then affirm it of the *Eye*, the Structure of which they must own, whether they will or no, to be unspeakably finer than all the Instruments for Sight that ever were invented by the Art of Men?

Ask then the greatest Mathematician, the most skilful Man in Optics, or Mechanics, whether he can be able to make a dark Chamber, that can be turned which way one will as readily and easily as the Eye; which, if turned towards remote Objects, can shorten itself and flatten its Glass, and upon the nearer approach of an Object, can make itself longer, and its Glass rounder, without standing in need of any other Assistance; yea (let the Cause thereof be what it will) that can adapt itself to the various Distances of Objects, and accordingly form at every time a different Object; that when the Light is too small, can dilate its Hole or Opening; and when the Light is too strong, can again contract the same, without the concurrence of any thing else besides the Disposition and Laws belonging to it?

Sect. XXIV. *The Sun necessary to Sight: And Convictions from all the foregoing Observations.*

Now to say no more, have we no reason to acknowledge the Goodness and Power of the Great Creator, who has made such unspeakably great Bodies, as the *Sun* is, (not to mention the *Moon* and *Stars*) subservient to these Purposes?

Purposes? who, to compleat this Design, and to make the Eye useful, has caused the Light to flow from thence in so vast a Quantity, as to be able to fill the immeasurable Space between us and the Firmament, even as far as to the Planet *Saturn* itself, which is supposed, and not without reason, to be enlighten'd by the *Sun*; who derives the Light itself with so unconceiveable a Swiftness down to our Eyes, that they may be continually supplied therewith, insomuch, that if such Swiftness, and all the other Properties of Light, of which we have been speaking (and of which we shall treat hereafter more particularly) were not demonstrable, they might justly be doubted of by every one.

Can any Body contemplate all these great Things that are necessary to make us *see*, and that co-operate as well within as without the *Eye*, and not think himself in the least obliged to him that has bestowed such Blessings on him? Who warns him thereby timely and from afar, of so many things, whether they be Advantageous or Prejudicial to him; who grants him the Pleasure of being able to View and Contemplate so many agreeable Colours in Fields, Trees, Flowers and the like; and to sum up all in one Word, who has vouchsafed him the Faculty OF SEEING; and who has made our Eye after a most astonishing manner, a perfect Stage or Theatre, from whence we may view all his Wonders, how small soever it be in Comparison of the Terrestrial and Celestial Bodies; making of his Light an admirable Pencil, for so the Mathematicians call the Composition of Rays represented in *Tab.* X. *Fig.* 3. by B S T *b*; as also in *Tab.* XI. *Fig.* 2. by B, C C, D D, E E, *b*; which proceeding from a Point as B, are, after due Refractions, united again in another Point *b*, by which means all His great and glorious Works of Sun, Moon, Stars, Earth, Sea, Mountains, as also Trees, Flowers, Men, Beasts, and whatever else is corporeal and visible are painted after an unimitable manner, in their true Colours and Lineaments upon the Bottom of the Eye?

Can it still be thought to be the result of mere Chance (since the Light, whilst it scatters and spreads its Rays assunder, is in itself improper to produce a clear and distinct Sight) that nevertheless, and only to render Men and other Living Creatures happy, Laws of *Refraction* were prescribed to this Light, by which its Rays were turned from *Divergent* into *Convergent*; that is, from scatter'd to united? Or, that it is without Wisdom, that this great and unformed Sea of Light, in all its most minute Particles, has submitted to these Laws, without departing one Tittle from them? Of which more hereafter.

Can any Body think it to be without a wise Design, that all the Limbs of a Humane Creature, from his Childhood to his Manhood, grow continually and proportionably greater, but the *Crystalline* Humour of the Eye only (forasmuch as our Sight depends upon the Figure thereof) does, without growing and increasing, always preserve the same Size and Form both in Men and Children? See this Remark in *Bergerus*, *pag.* 407.

CONTEMPLATION XIII.

Of the Hearing.

SECT. I. *The Instruments of Hearing unknown.*

NOW if we pass from the Sense of *Seeing* to that of *Hearing*, how small Progress has the Labour of Enquirers been able yet to make, in order to penetrate into the true manner how this last is perform'd, it will only be necessary to quote the Expressions of the famous Anatomist, Monsieur *du Verney*, in the Preface of his most laudable Treatise about *the Instruments of Hearing*: *Among all the Instruments which Beasts use for their Service, those of the external Senses are least of all known to us; but nevertheless, none of 'em all are attended with so much Obscurity as the Instruments of Hearing.* The same is likewise acknowledged by *Valsalva.* It must not therefore be expected, that we shall set the Wisdom of the adoreable Creator in this Case, either in a full Light, or even demonstrate it so plainly as has been done in the Business of *Seeing*; this must be the agreeable Employment of following Ages, when it shall please the Great Creator to give them a Clew to this Labyrinth, and further, to bless their Enquiries, after repeated Discoveries, concerning the Instruments of *Hearing*, of *Sound*, and of *Musick.*

SECT. II. *But they are still sufficient to prove the Wisdom of GOD.*

HOWEVER, to shew that notwithstanding Humane Wisdom is not yet capable of finding out the right Uses of all those Instruments that belong to the Sense of *Hearing*; yet the Structure thereof, as far as it has been hitherto discover'd, is sufficient to prove the wonderful Wisdom of the Creator to an Enquirer after Truth; and so convince an Atheist too, if he be not more Obstinate than Ignorant: Since we have not here undertaken to describe a compleat Anatomy of these Parts, it will not be useless to transfer the following Figures from the Tables of *Valsalva*, which represent to the Life the Structure of the Instruments that serve for *Hearing* with respect to each other; so that from them, with some others which we shall add for greater Clearness, the Reader will be able to form a rough Conception thereof.

SECT. III. *The External Structure of the Ear.*

LET us then begin from the External Structure of the Ear, which every one may see in other Treatises.

Can any one suppose that it is Accidental, and without Design, that two Ears are placed upon the Head; which serve to receive Sounds by the Mediation

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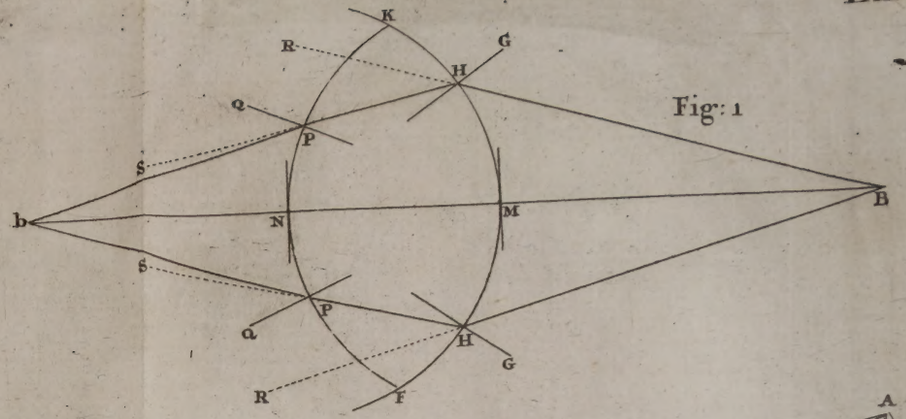

Fig: 1

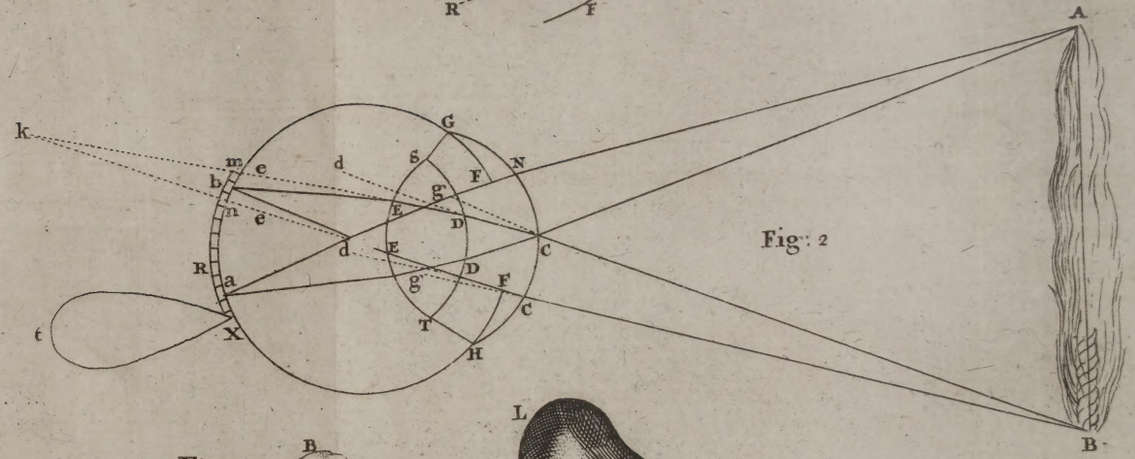

Fig: 2

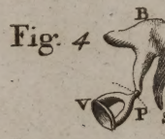

Fig: 4

Fig: 5

Fig: 7

Fig: 3

Fig: 6

diation of the Air; as may be seen in several Beasts, who, as the Sound comes from certain Places, are wont to turn the Cavity of their Ears that way; as likewise in Men, who, when one of their Ears fail them, endeavour to repair that Defect, by holding the Hollow of their Hand behind it? And can one see, without acknowledging a Design of the Creator, that when the Sonoriferous Air is come into the Cavity of the External Part of the Ear, it meets with a moveable Protuberancy at the Mouth of the Auditory Tube (called by the Anatomists the *Tragus*) by which the Air is hinder'd from avoiding this Entrance of the said Tube, and compelled to run into its Orifice or Mouth?

Now forasmuch as the Ear, if it were composed only of a soft and flabby Matter, like the Membranes, would hang down over the Orifice of the Auditory Tube, and hinder Hearing; or if it were of a harder and bony Substance, would occasion Inconveniencies in our lying down and otherwise: How manifest is the Wisdom of the Creator, who has composed the said whole Ear of Membranes supported with Cartilages? by which means it is endowed with an Elastick Faculty (as you may observe when you bend the Ear with your Hand, and let it go again) to the end, that it may redress itself, and return to its former State in all Accidents; and perhaps too, as some think, to promote the Tremulous Motion of the Sonorous Air. This is certain, that the Auditory Tube is at the beginning of it, made of the same Cartilaginous Substance with the Ear; but farther in it, consists of Bone only, as is sufficiently known to the Anatomists.

SECT. IV. *The Auditory Tube, and the Membrane called the* Tympanum, *or Drum.*

To say something more of this, let (*Tab.* XI. *Fig.* 3.) L L be the Circumference of the extreme Part of the Ear, and K the circular Cavity that appears therein (called the *Concha*, or Shell) and which can be seen outwardly; and in which is also the Orifice of a Tube A C, which extending itself internally in the Head, is called the *Auditory Tube.*

This consisting of a Cartilage about that Part of the Ear marked A, and afterwards as far as C, of a Bone only, is cloathed on the inside with a Skin or Membrane, which in this Figure is represented alone without the Bone and Cartilage; and at the End of it F, it is shut up by a Membrane which is round, dry, thin, solid and transparent, and which is called the *Drum* of the *Ear.* But some are of Opinion, that there is a small Orifice in this Membrane, which seems to be in some measure likely, because such as take Tobacco have been observed to convey the Smoak thereof from the Mouth thro' the Ears.

And thus we see how the Sonoriferous Air, admitted into that Part of the Ear L L, and collected in the *Concha* K, enters into the Auditory Tube, and passing from A to C, strikes against the Membrane F, and puts it into Motion.

SECT. V. *The Cavity called the Drum, the Bones of the Ear, and the* Chorda *or Little String.*

BEHIND the Membrane of the Drum, more inwardly in the Head, there is a certain Cavity, which the Anatomists call the *Tympanum* or Drum, upon which

which you muſt ſuppoſe that this Membrane is extended much after the ſame manner as the Skin of a Kettle-Drum.

In this Cavity Anatomiſts obſerve ſeveral wonderful Things, ſome of which are contained within it, and others in its Circumference: The firſt things within it, are the four little Bones of the Ear, and a ſmall Nerve, called the *Chorda Tympani*, or String of the Drum; to ſay nothing here of the Muſcles, and other Singularities that occur therein. The other things conſiſt moſtly in the Openings that appear in the Bone of the Drums Circumference, whereby the Cavity thereof has a Communication with other Cavities, either with, or without the intervention of Membranes.

Theſe Auditory Bones (*Tab.* XI. *Fig.* 4.) are found to be four in number, C S is the *Hammer*, B P the *Anvil*, P V the *Stirrup*; and between the Anvil and Stirrup there lies, at P, a ſmall roundiſh Bone, which makes the fourth in Number.

Between two of theſe Bones (*Tab.* XI. *Fig.* 3.) there is a little Branch of a Nerve E O, or *String* of the *Drum*

Sect. VI. *The Motion of thoſe Inſtruments.*

Now if we ſuppoſe that the Tail S, of the Hammer C S, is faſtened to the Membrane of the Drum, which lies there under it, we may obſerve at the ſame time, that this Membrane being moved by the Sound, that paſſing into the Auditory Tube A C, ſtrikes upon it, will likewiſe move the Hammer C S, as that will do the Anvil B P; by which laſt, and by the fourth little Bone P (*Tab.* XI. *Fig.* 4.) the Stirrup V P, will likewiſe be moved: And ſo the little String or Nerve E O (*Tab.* XI. *Fig.* 3. when the Hammer C S, and the Anvil B P, are ſtirred by the Membrane of the Drum,) will always follow the Motions thereof: So that from hence it appears, that the Motion of the Membrane of the Drum, communicates itſelf to all theſe little Bones, and to the *Chorda Tympani*.

Sect. VII. *The Openings in the Circumference of the Cavity of the Drum.*

To have a true Notion of the Circumference of this Cavity, which an unskilful Perſon muſt take care to diſtinguiſh from the Membrane of the Drum, ſince *Valſalva* has not drawn it entirely, but only the Openings that are therein; you muſt ſuppoſe it to be a Cavity that comes behind the Membrane of the Drum (*Tab* XI. *Fig.* 3.) and encompaſſes theſe little Bones: Or you may conſult hereupon the Figures thereof in Monſieur *du Verney*, which, if we ſhould here reckon them up, would require too many Explanations.

In this Circumference of the Cavity of the Drum Anatomiſts do then find;

1. The Opening of the inmoſt Part of the Auditory Tube A C (*Tab* XI. *Fig.* 3.) which is ſhut up by the Drum-Membrane F.

2. The Opening H of the Tube H G I, called the Trumpet of *Euſtachius*, which terminates at I, in the furthermoſt Part of the Roof of the Mouth; ſo that the Air paſſing thro' it from the Mouth, from I to H, can enter into the Cavity of the Drum, and be again diſcharged the ſame way: The Wiſdom of the Creator does wonderfully appear, in making this Orifice in the Roof

of the Mouth after such a manner, that the fresh Air drawn in by the Nostrils, is directed in its way thither by a little Protuberancy; and when it returns from the Lungs, charged with Vapours, it passes by this Orifice more easily than it can enter into it.

Valsalva shews by Experience, that this being stopt, the Ear on the same side is immediately deaf; but when open'd, hears again.

And this, according to all Appearances, is that Passage for Sounds, by the help of which, Men that have been entirely Deaf, have sometimes been able to tune a Musical Instrument, and others have been found to hear by the Mouth; for which purpose, a little Stick, held between the Teeth, or set against it with one End, has oftentimes done great Service, whilst the other End, resting upon the Instrument, serves for a Passage to the Tremulous Motion of the Air. The Passage of the Tobacco Smoak from the Mouth to the Ear, of which we have already spoken, may perhaps be traced after the same manner.

3. The little Part of the Bone D, is the side of a *Sinus*, which makes the Cavity of the Drum larger, and is continued to the Cavity of another Bone, called the *Apophysis Mammillaris*, or *Mastoides*. In the first Entrance of this *Sinus*, the sharp End of the Anvil rests, as may be seen at D.

4. In the upper Part of this *Sinus*, *Valsalva* has discover'd several Holes, by which there is a Communication between the Cavity of the Drum and that of the Skull itself.

5. There are yet two Openings in the Circumference of the Drum; the first of 'em are called the *Oval Window* (*Tab.* XI. *Fig.* 5.) *o*, and this Opening is stopt by the *Stirrup*.

6. The other is called the *Round Window p*; which is shut by a Membrane like that of the Drum. You must suppose, that both these Openings, *o* and *p*, are here in one Bone, which is a part of the Circumference of the Drum's Cavity; and that all these Threads and little Tubes 1, 2, 3, 4, are quite out of the Drum's Cavity, which we have put out of the way, that they mayn't hinder the Sight of 'em.

Sect. VIII. *The Labyrinth, or Maze of the Ear.*

These two Oval and Round Windows open the way for Enquirers to the last and most inmost Cavity of the Ear; which, by reason of its wonderful Figure, is called the *Labyrinth*. Being strip'd of the Bones that lie about it, it shews itself as described in the Table, only the End or Point of this Snail's Course 4, must be shewn somewhat rising from the Paper, and not lying in the same Place with all its Windings, just as you see in the Snails themselves, their Point to be a little elevated. I add this Remark, because mentioned by *Valsalva*. You may see it better delineated in *Tab.* XII. *Fig.* 1. but with the same Fault as *Tab.* XI. *Fig.* 6. and the better to shew all the Parts, the Labyrinths are placed in a different Situation.

The Parts of this last Cavity (the Labyrinth) are commonly divided into three; namely, First, three Semi-circular Vessels, 1, 2, 3. Secondly, the *Cochlea*, or Snail 4; and Thirdly, a Cavity called the *Vestibulum*, or Porch, which lies between the two, and which, for greater clearness, is represented open (*Tab.* XI. *Fig.* 6.) To say a word or two of each. We

We ſee that theſe Semi circular Veſſels, 1, 2, 3, have an Opening at each End into the *Veſtibulum*; but that two of 'em, 1 and 2, are united in one Veſſel at 5 and 6: And therefore, that there are not ſix but five Orifices in the whole: Moreover, we ſee on the ſide oppoſite to the Porch, the *Cochlea* 4; this is divided according to its Length and Bending into two particular Tubes by a kind of a *Septum*, or Partition-Membrane; which likewiſe, according to its Length, conſiſts of two different Sorts of Matters; the one is membranous, which *Valſalva* (ſee his *Tab.* VIII. *Fig.* 7.) thinks is probably formed from a Branch *e*, of the ſoft Auditory Nerve ſpread out into a Membrane (*Tab.* XI. *Fig.* 7.) And the other kind of Matter is dry, thin and rough, according to *Du Verney*, and between the Solidity of a Cartilage and a Membrane, as *Valſalva* ſays of it. That at leaſt ſeems to be true, that this Matter renders the *Septum* very fit for propagating the Tremulous Motion of the Sound.

Of the two Tubes which are made by this *Plaat* in the *Cochlea* 4, one is ſhut up in a Membrane; and the round Window *p*, of which mention is made above (*Tab.* XI. *Fig.* 5.) in the Opening itſelf: So that between this Tube, or rather between the half Cavity of the *Cochlea* and the Drum's Cavity, nothing but this Membrane does appear.

Tab. XI. *Fig.* 6. *r* is likewiſe the Orifice of another Tube, which is open at the *Veſtibulum*.

The Anatomiſts name both theſe Tubes, into which the Cavity of the *Cochlea* 4 is divided, the *Scalæ*, or Stairs.

Laſtly, we find that the *Veſtibulum* (beſides the five Openings of the Semicircular Veſſels, one of the *Cochlea*, and ſtill five others thro' which the Auditory Nerves paſs, and by which theſe Openings are ſtopt) has yet one more repreſented (*Tab.* XI. *Fig.* 5.) by *o*, and *Fig.* 6. by *q*; *viz.* the aforemention'd Oval Window, which is ſtopt by the little Bone of the Ear called the Stirrup; yet in ſuch a manner, that the Membrane which is between that Bone and the Edge of this oval Opening or Window, gives a Liberty to the Stirrup to be moved upwards and downwards.

Sect. IX. *The Auditory Nerves.*

Before we go any farther, we muſt ſay ſomething of the Auditory Nerves, the ſoft Parts whereof *c d* (*Tab.* XI. *Fig.* 7.) being divided into five Branches, paſs thro' the aforeſaid Openings into the *Veſtibulum*, where behing expanded, they compoſe the Membrane of this *Veſtibulum*; and from this Membrane likewiſe, there proceed five others, which entring into the Semi-circular Veſſels, and coming with each other from both ſides, are united n one Membrane. You may ſee 'em in this Figure, which appears ſufficiently in *Fig.* 6. If inſtead of the Tubes you ſuppoſe you ſee the Membranes which are there, and which are made of the expanded Auditory Nerves.

So likewiſe, according to *Valſalva*, the little Branch of the Nerve *e* in the *Cochlea*, produces the Membrane *g*, which, as we ſaid before, makes one ſide of the *Septum*, that divides the whole *Cochlea* into two Tubes.

Sect. X. *All the Inſtruments of Hearing ſhewn.*

After all theſe Particulars, we ſhall proceed to repreſent the entire Structure of the Inſtruments of Hearing jointly with one another, and at the ſame time, give you a brief Account of the Opinions of the principal Anatomiſts concerning their reſpective Uſes: You may ſee them in *Tab.* XII. *Fig.* 1. which, to range them in order as they appear, did not coſt a little trouble to *Valſalva*, as he himſelf ſays of it.

Here then we find the Ear repreſented, not as it is ſeen before, or as it is extended towards the Face; but inflected a little towards the hinder Part of the Head, to ſhew all the other Matters more plainly.

A A is the Ear, in which the Sound is incloſed; and B the *Cochlea*, or Shell, in which the ſonorous Air is collected, which, paſſing from thence into the Auditory Tube C C, ſtrikes upon the Membrane of the Drum *c g o*, and thereby communicates a tremulous Motion to the ſaid Membrane.

Sect. XI. *An Experiment ſhewing that the Auditory Tube increaſes the Sound.*

It muſt not be thought that this is ſaid without any ground, ſince it is very probable, that the Air paſſing thro' the *Cochlea* B, and the Auditory Tube C C (which together make a natural Speaking-Horn or Trumpet) ſtrikes much more ſtrongly upon the Membrane of the Drum that ſhuts the ſaid Tube, than if it ſtruck againſt the ſaid Membrane, without paſſing thro' this Tube.

This is plain in ſuch as are Deaf, and who are obliged ſometimes to put into their Ear, either a crooked or ſtrait Tube, the Mouth of which is large, and the lower part narrower, in order to hear the better.

And if a Man that is not deaf has a mind to make the Tryal, let him take one of thoſe Speaking-Trumpets that were invented in the laſt Century (ſee *Tab.* XII. *Fig.* 2) A E, and ſet the narrow Part of it againſt his Ear, and let ſome Body whiſper ſoftly at the wide Part E; and he ſhall find, tho' the Tube be about ſix Foot long, as mine is, that he will hear the Speaker very plainly and diſtinctly, even at the time when other Perſons ſtanding much nearer to the Mouth of him that ſpeaks, and liſt'ning with all the Attention they can, will not be able, by reaſon of the lowneſs of his Voice, to hear or underſtand any thing he ſays.

After the ſame manner we likewiſe perceive, that the Sound produced by blowing thro' a Trumpet or Horn, is heard incomparably louder than that which any Man can make with his Mouth only.

Sect. XII. *Sounds produce a Tremulous Motion in the Drum-Membrane, ſhewn experimentally.*

Now to ſhew farther, that the Air operating more ſtrongly upon the Membrane of the Drum *c g o*, thro' this natural Auditory Tube A A B C C (*Tab.* XII. *Fig.* 1.) produces therein a ſhivering or tremulous Motion; one might firſt inſtance in the manner that all reſounding Bodies are moved, which, vibrating ſwiftly backwards and forwards, ſtrike againſt the *Circum-*

ambient Particles of Air, and ſo communicate this tremulous Motion. One may perceive this ſame tremulous Motion very ſenſibly in Bells, in the Strings of Muſical Inſtruments and other things, by laying ones Finger or any other Matter upon them when they are made to ſound; and very plainly in the known Experiment of a Drinking-Glaſs, with a little Water in it, by wetting the Finger and preſſing it round the Brim; and at the ſame time that it yields a Sound, if you place the other Hand at the Foot or Bottom of the Glaſs, you may feel the ſaid tremulous Motion.

And to ſee, by way of Compariſon, how the Air is moved by ſuch a reſounding Glaſs, you need only pour as much more Water in it, which will fill it almoſt to the Brim, when preſſing the ſaid Brim round again with the Finger, you will viſibly diſcover in the Water, the tremulous Motion occaſion'd by the Glaſs; juſt ſo is the Air likewiſe moved.

Sect. XIII. *Other Experiments proving the ſame thing.*

But not to diſcourſe too long nor too deeply about the Nature of Sounds, which are not yet fully known to us, this is ſufficiently certain, that after what manner ſoever the Air be put into Motion, in order to produce Sounds, it is capable of cauſing the Bodies againſt which it ſtrikes to tremble.

Now, to ſay nothing here of thoſe Motions which the Sound of a Cannon produces in the Air, and by which it cauſes Doors and Glaſſes, with many other ſolid Bodies, not only to tremble, but to burſt in pieces; this is very plain, that if you ſtrike with your Finger upon the Thread or String of a Muſical Inſtrument, for Inſtance a Violin, the other Hand in which you hold the ſaid Inſtrument, will in ſome meaſure feel the Wood to tremble.

But now to ſhew the Analogy thereof with the Ear, about which we have been treating; take away the Mouth-Piece of the Speaking-Trumpet, A, B, C (*Tab.* XII. *Fig.* 2.) and inſtead thereof, let a dry thin Hog's Bladder be ſpread over the Orifice as ſmooth and tite as may be; or in caſe the Brim or Edge of the ſaid Trumpet B C, be armed with a kind of Teeth, as ſome are for Ornament-ſake, and that there be danger from thence of burſting the Bladder in the Expanſion thereof, you may put a four-double Paper, with a great round Hole in the middle, upon thoſe Teeth, before you ſpread the Bladder over them; this being done, let the Trumpet, with its largeſt Orifice D F, be placed upon the ſide of two Chairs, ſo that it may ſtand ſtreight up, and the Bladder be on the Top at B C.

Now in caſe you ſhould lay three or four little Feathers of a Quill upon the ſaid Bladder, and cauſe a Man lying upon his Back upon the Floor, with his Head between two Chairs, and his Mouth directly under the middle of the Tube E, to call or ſpeak out aloud, you ſhall perceive, that the Sound ſtriking upon the Bladder, will produce a tremulous Motion in the ſame, and in the little Feathers lying upon it; which Motion, or Trembling, may be likewiſe felt, if you hold the Tube in your Hand, and lay your Finger upon the Bladder at B C, when any Body ſpeaks whoſe Mouth is placed at E.

Thus

Thus then we see (taking the Speaking-Trumpet for the Auditory Tube A A B C C, *Tab.* XII. *Fig.* 1.) and the Bladder for the Drum-Membrane, which is expanded over the Auditory Tube at *c g o* O, that the said Membrane must be affected with a tremulous Motion, by the Sound entering the Ear, as also the Hammer *n*, whose Stalk or Handle is fasten'd to the Drum-Membrane.

SECT. XIV. *The Tremulous Motion of the Auditory Bones.*

NOW by this Hammer must the little Nerve *c* 7 (which shews itself here between the Hammer *n* and the Anvil *m*) be likewise moved; of which we shall say something more hereafter. But it is particularly plain that the Hammer *n*, being moved by the tremulous Motion of the Drum-Membrane, propagates the same Motion to the Anvil *m*, and by that to the Stirrup *p*.

The Stirrup *p*, which does here close the Oval Orifice in the Porch 4, both by itself and the Membrane that surrounds it (this Orifice does not appear very plain here, but you may see it in *Tab.* XI. *Fig.* 5. at *o*, and *Fig.* 6. at *q*) being thus put into a tremulous Motion, both by the Sound and by the Trembling of the Membrane of the Drum, and the rest of the Auditory Bones; we likewise see that the Air in the Porch 4, and moreover in the Semicircular Vessels 1, 2, 3, and in the one Tube, or half of the *Cochlea* 5, will be moved; and also through the round Orifice *p*, (*Tab.* XI. *Fig.* 5.) the Air in the other Tube, not like the former (*Tab.* XII. *Fig.* 1.) by the Auditory Bones, or by the Hammer *n*, the Anvil *m*, and the Stirrup *p*; but by the Motion of the Air in the Cavity of the Drum, which is to be found between the Drum-Membrane and this round Orifice; which Air being moved by the Membrane of the Drum, and likewise by that Membrane that closes the round Orifice *p* (*Tab.* XI. *Fig.* 5. and the Air, *Tab.* XII. *Fig.* 1.) that is behind in the other half Tube of the *Cochlea* 5, will be moved. This is the Opinion of Monsieur *du Verney*, about the round Window, from whom *Valsalva* does herein somewhat differ: They that please may consult 'em both, or stay till the Uncertainty of the Use of this round Orifice be removed by future Experiments. But to proceed:

SECT. XV. *The like Motion in the Membrane of the Labyrinth.*

THIS Air being put now into Motion throughout the whole Labyrinth 1, 2, 3, 4, 5 (*Tab.* XII. *Fig.* 1.) the Membranes (that are therein, and are represented by *Fig.* 7. *Tab.* XI.) or rather the Auditory Nerve 6, must needs be moved thereby; which Nerve enters this Labyrinth thro' five Orifices (*Tab.* XII. *Fig.* 1.) three of which are seen on this side the Porch like so many Points; and being there, and spreading out its Branches into Membranes (when they are moved by the Air) as well in the Porch as in the three Semi-circular Vessels, and the *Cochlea*, the Sense of Hearing is thereby produced.

So that finally these Nervous Membranes in all the Cavities and Tubes of the Labyrinth 1, 2, 3, 4, 5, seem to be the Instruments by which, and the Labyrinth itself the place where, the Hearing is formed, because the Motion

of the Sound does there affect the Auditory Nerves, or the Membranes produced by the Expanſion of the ſame.

Now that this is not advanced by many, without good Grounds, ſeems to be in ſome manner proved by an Obſervation which *Valſalva* made upon the Body of a deaf Perſon. *Ch.* II. §. 10. where the Membrane that encompaſſes the Stirrup, and ſhuts the Oval Orifice, was found to be all Bone, and for that reaſon the Stirrup was immoveable, which, according to him, was the Cauſe of that Deafneſs; to which we may add, that the Drum-Membrane being broken, the Hearing does not immediately fail, but only after a good while, when the other Inſtruments of Hearing, lying too naked and expoſed to the Air, are perhaps corrupted. So that properly the Drum-Membrane does not ſeem to be the immediate Inſtrument of Hearing.

Sect. XVI. *Convictions from ſome Particulars.*

I now leave it to the Judgment of an Atheiſt himſelf, how many things relating to the Uſes of theſe Inſtruments of Hearing may be ſtill concealed from us; or, whether ſo many as are hitherto known to us, are formed and fixed in the Place where we find them by mere Chance, or without a wiſe Deſign?

Dares he now aſcribe the Figure of thoſe little Trumpets or Horns that Deaf People make uſe of, to Chance, or ignorant Cauſes? Can he then with the leaſt Appearance of Reaſon, advance ſuch Sentiments of this which is found in the Ears of all Men L L, and is repreſented in *Tab.* XI. *Fig.* 3. by the *Concha* K, and the Auditory Tube A B C.

Eſpecially knowing, as he does, the Inconveniencies which any little Things or Inſects produce, when they get into that Tube; and ſeeing beſides, that that Veſſel is encompaſſed with a number of ſmall Glands at A, which have likewiſe their own little Veſſels, from whence a tough and yellow Matter is continually filtrated; the Uſe whereof is not only to preſerve the Tube in a proper State of Moiſture, ſo that it may not be too much dryed by the Air, nor yet render'd too ſoft and flabby, if the ſaid Matter were thinner; but chiefly to ſtop the way to the innermoſt Part of the Ear, and barricade it againſt little Flies and other little Animals by the aforeſaid tough Matter, and alſo by the little Hairs that grow therein; and in caſe any of thoſe little Creatures ſhould have inſinuated themſelves too far, the bitteriſh Taſt of that Matter will deter them from advancing any further.

The Wonders of this Structure of the Ear, ſo far as they relate to the little Muſcles placed therein, may be ſeen in the Books of thoſe who have learnedly treated of the ſame, ſuch as *Valſalva*, *du Verney*, and others: *d* is one of thoſe Muſcles repreſented in *Tab.* XII. *Fig.* 1. as ſeparated from the Bone-Tube in which it is placed; which alſo ſerves to draw the Hammer, and thereby more or leſs to expand the Membrane of the Drum, and, together with the other Muſcle *f f*, to open at the proper time the Tube H I, which runs from the Cavity of the Drum to the hindmoſt part of the Roof:

Roof: At *g* we see a small Muscle, which is implanted in the Head of the Stirrup, and which can stretch more or less the little Membrane that shuts the Oval Orifice, in order to render it more serviceable to the Motion of the Sound: But this we shall pass by.

SECT. XVII. *The Difference between the Instruments of Hearing in Young and Grown People.*

NOW if the Wisdom of the Creator does not palpably appear from all the foregoing, let any reasonable Body judge, when he sees that in *Tab.* XII. *Fig.* 1. the little Bones of Hearing *n, m, p,* and those that compose the Labyrinth 1, 2, 3, 4, 5, are of the very same Size in a little Child as in a grown Man; whereas all other Bones do mostly grow with the Body; the reason of which, as it should seem, is, that in case the Instruments of Hearing should alter, the Voice of the Children themselves, of their Parents, and other Sounds already known to Children, might, by the growth of these Instruments, become strange and uncouth to them, and so occasion Mistakes and Confusion.

And to be convinced, that this happens with Design, and merely by the Wisdom of the Creator, we need only take notice, that where it is necessary that all these things should remain in the same State in a Child and in a grown Person, the same does accordingly happen; but when any Alteration is necessary, that also happens: Accordingly in a grown Person it is necessary that the Auditory Tube B C C, should be wholly open to the Membrane of the Drum *c, g, o, c,* and the Membrane of the Drum itself dry, and not too flabby; But if this should happen in the same manner in Children, that Moisture with which they are encompassed before their Birth, would render the Membrane of the Drum too soft and flabby to be of use to them afterwards: From whence it is, as Anatomists observe, that the Auditory Tube in new-born Children is narrower, and stopt by another kind of Matter, insomuch, that the Humidity of the Matrix cannot approach it; which stopping Matter is found to disappear of itself in a few Days after the Birth, to accustom the Children by degrees to the Impression of the Air upon the Membrane of the Drum, and so to the Sense of Hearing, of which they are deprived even after their Birth, so long as this Obstruction lasts in the Auditory Tube.

SECT. XVIII. *The Instruments of Hearing are unnecessary without Air. Convictions from thence.*

NOW, as the Eye without Light, so this wonderful Structure of the Instruments of Hearing, would be in a manner useless, if He, that takes such great Care of all his Creatures, had not vouchsafed to encompass that Globe upon which they live with a vast Ocean of Air. Does not this then administer an Occasion to us also, to praise the Goodness and Wisdom of the Creator, who has been pleased so to adjust these Instruments of Hearing, that whilst Men live and breath in the Air, they are exactly adapted to discover to us, after such a wonderful Manner, the Motion thereof, by means of an Impres-

Impression which the Sound produces in us; and which is only applicable to this Sense of Hearing?

Will any one dare to maintain, if he saw a Ship sailing with all its Tackle, that the Ropes, Sails, Pullies, and whatsoever else is necessary to adapt it to the Wind, are put into such a State by mere Chance, or without Design; and yet that every one of them was very useful in causing the Ship to move? And is it not much more unreasonable to assert the same of these much more wonderful Things, which as to the manner of their Operation, have hitherto been inscrutable? For these are not governed by a strong and sensible Motion of the Air, such as the Wind is, but are adapted to a much more secret and insensible Motion thereof, with the Assistance of several Muscles, which dilate or contract these Instruments of Hearing: And yet it must be confess'd, that the Uses and Advantages of such a Motion are much greater than that produced by the Wind in a Ship, in which latter a very few may be concerned, but the former affects all living Creatures; and the Benefit thereof is communicated to them after the most convenient Manner, and even without any Concurrence or Trouble on their Part.

Sect. XIX. *The Nerves that are moved in Hearing.*

To proceed now to those other Matters of which we promised to say something in the following Discourse: We have shewn before, in *Tab.* XI. *Fig.* 3. a small Nervous Body E O (which in *Tab.* XII. *Fig.* 1. is represented by *c* 7.) This is observed to run across over the Membrane of the Drum, between the two Auditory Bones, *viz.* the Hammer C S, and the Anvil P P; and forasmuch as the Hammer C S is fasten'd to the said Membrane of the Drum, 'tis plain enough, that that Membrane being moved by Sounds, such Motion must necessarily be continued to the Hammer, and to the said Nervous Cord or String E O: So that in every Motion of the Membrane of the Drum, that is, as often as one hears any thing, this little Nerve E O, is put into a tremulous Motion.

Sect. XX. *The Use of the said Nervous Cord.*

Concerning the right Use of this little Nerve the Opinions of the Anatomists are various, all of 'em looking upon it as a thing sufficiently obscure. It is called by the Ancients *Chorda Tympani*, or the String of the Drum, and esteemed to be of the same Use as the Strings of the Soldiers Drums.

Mr. *Maurice Hoffmann* in his *Idea Machinæ*, p. 232. has collected the several Notions of the Learned about this Nervous String. *Fallopius*, says he, was uncertain what it was: *Eustachius* takes it for a Branch of the Nerves of the Fourth Pair; notwithstanding which Mr. *Gasper Hoffmann* acknowledges ingenuously, that he did not know what sort of a Body this was, nor to what End, nor where it was inserted; and thought that it might be an uncertain Work of sporting Nature, and that a great many were mistaken concerning it. Whereupon *Riolan* having since answer'd him, says, that it is a nervous Fibre derived from the Auditory Nerve: Finally, Monsieur *du Verney* has irrefragably

proved, that this nervous Cord is a Branch of the Fifth Pair, which proceeding forwards, joins it self to the hard Auditory Nerve.

The said Monsieur *du Verney* lays down the Use thereof in his Treatise *de l' Organe de l' Ovil, p.* 51, 52. saying, that it communicates Branches to the little Muscles of the Auditory Bones, and what else there may be in the Cavity of the Drum, in order to produce Motion.

Monsieur *M. Hoffmann* supposes that it serves to communicate Motion and Sensation to the Drum-Membrane, at least to give it is proper Tension.

Touching this String, the Reader may consult *Valsalva*, who having written later than the above-mention'd Gentleman, has declared his Opinion with some Warmth in his Accurate *Description of the Ear, Cap.* II. §. 22. These are his Words as they stand there; *Moreover, that this nervous Branch runs so naked and undiscover'd, so simple and alone, so regularly and so constantly thro' the Cavity of the Drum, and particularly that it lyes so between the Auditory Bones, that it is immediately put into Motion as soon as ever the said Bones are moved; all these things shew, that there is some great Mystery of Nature concealed in this Branch, and have therefore induced me frequently to contemplate the same both with my Eyes and my Mind, being desirous to find out something perhaps new in the Dissection, or at least the Causes thereof.* After which he tells us what his Thoughts were concerning it, and what he had begun to discover therein, and so concludes with these Words: *But since I have not yet had an Opportunity to employ so much Pains as I was desirous, and as was requisite in this Matter, I shall content my self with having made known my Intentions and Purposes, and say no more about it at present.*

This Gentleman does likewise own, that this Branch lyes between the Fifth Pair and the Auditory Nerve; but adds, that he can't see, why we may not as well take it for a Branch of this Auditory Nerve, carried on to the Fifth Pair, as a Branch derived from the Fifth Pair to the said Auditory Nerve: But whether we maintain it to be the first or the last with Monsieur *du Verney*, it is certain, that this String has likewise a Communication with the Fifth Pair; and that being put into Motion by Sounds, it cannot avoid continuing such Motion, both to the Fifth Pair and to the Auditory Nerves.

I have been more prolix in relating the Sentiments of the Principal Anatomists upon this Matter, to shew that this little nervous Cord has occasion'd very serious Reflections among several Persons, and that many have suspected, that there is something strange and uncommon therein: And I should not have offer'd my own Opinions concerning the Operations of the said Cord, and the Purposes for which it seems to be made, were it not to convince the Atheists and Unbelievers, or at least Weak and Wavering Christians, that they will find something in the Structure and Contrivance of this String, that may excite in them not only Admiration, but also Reverence for the adorable Maker of it. To propose it therefore briefly:

Sect. XXI. *The Fifth Pair of Nerves serve to excite the Passions.*

How much the Fifth Pair of Nerves contributes towards exciting our Passions or Inclinations, with respect to the *Intercostal Nerves*, which issuing frequently

quently with a double Branch out of the said Fifth Pair, liberally communicates Sprigs to all the Parts of our Body, and causes Motions therein, may be learned from the Words of that great Enquirer into the Nerves, *Vieussens*, *p.* 236. in 8*vo.* who says, That *the said Pair is not only carried on to the Eyes, Nose, Palate, Tongue, Teeth, and all the Parts of the Mouth and Face, but that it likewise derives its Branches to every thing that is in the Breast and Belly, and is even continued down to the Feet by the Intercostals*; Adding farther, *p.* 327. that this Communication of the Branches of the Fifth Pair is, among other things likewise, the Cause why, pursuant to the various Motions that are produced in the Brain, all the Parts of the Body, and particularly of the Breast, are differently affected, and the Signs of our Inclinations impressed upon our Faces, which are altogether adapted to those Passions that are moved; and accordingly by the Changes of our Countenances, the several *Emotions*, or Affections, of Love and Hatred, of Joy and Sorrow, of Fear and Boldness, are clearly expressed.

Sect. XXII. *The* Dura-Mater *produces the like Emotions.*

Secondly, How much the Motions of the *Dura Mater*, which encompasses all the Nerves, do likewise contribute to the producing these Passions and Emotions in the Mind, is known to Surgeons when they touch the same, and to Physicians too, very frequently in the Distemper called the *Phrenitis* Frensy; in which it appears, that by the pricking of this Membrane (whereby its Expansion is augmented, and the Manner of Motion alter'd) confused Thoughts and extravagant Passions, sometimes Weeping, then again a sudden Fit of Laughter; one while Fear, another while Boldness and Anger; and innumerable other irregular Motions in Actions and Words, without any external apparent Cause, are produced in the poor Patient. Now this great Instrument of so many Actions, this *Dura Mater*, has many of its Nerves from the Fifth Pair, as the said *Vieussens* has shewn in several Places, so that that is likewise moved thereby.

Sect. XXIII. *The Eighth Pair produces the same Effects.*

Thirdly, It may be likewise observed, from the said *Vieussens*, *p.* 347. that in many Cases, the Nerves of the Eighth Pair, which the Ancients name the *Wandering Nerves*, or *Par-vagum*, encompass those of the Fifth Pair in their Operations; and consequently in many Places, by the Interposition of the Nervous Branches, those of the Eighth Pair are inserted in the Intercostals which proceed from the Fifth Pair. And how much therefore those of the Eighth Pair do likewise help to excite the Passions, appears from the same Author, *p.* 347, and 348. where he says, *Since the Eighth Pair has a Communication with the Auditory Nerves about the Origin thereof, we find the Reason why not only different Passions are excited in the Soul, according to the differences of Sounds; but also, why the Heart and other Parts, yea, even the whole Body, are variously affected thereby.*

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TAB. XII

Fig. 2

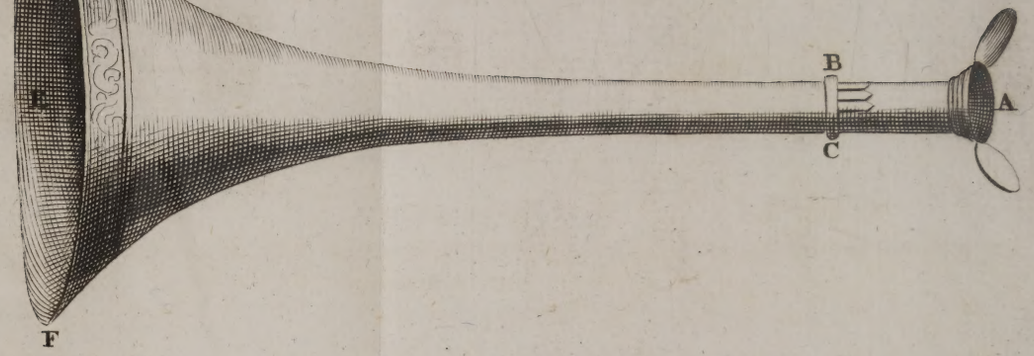
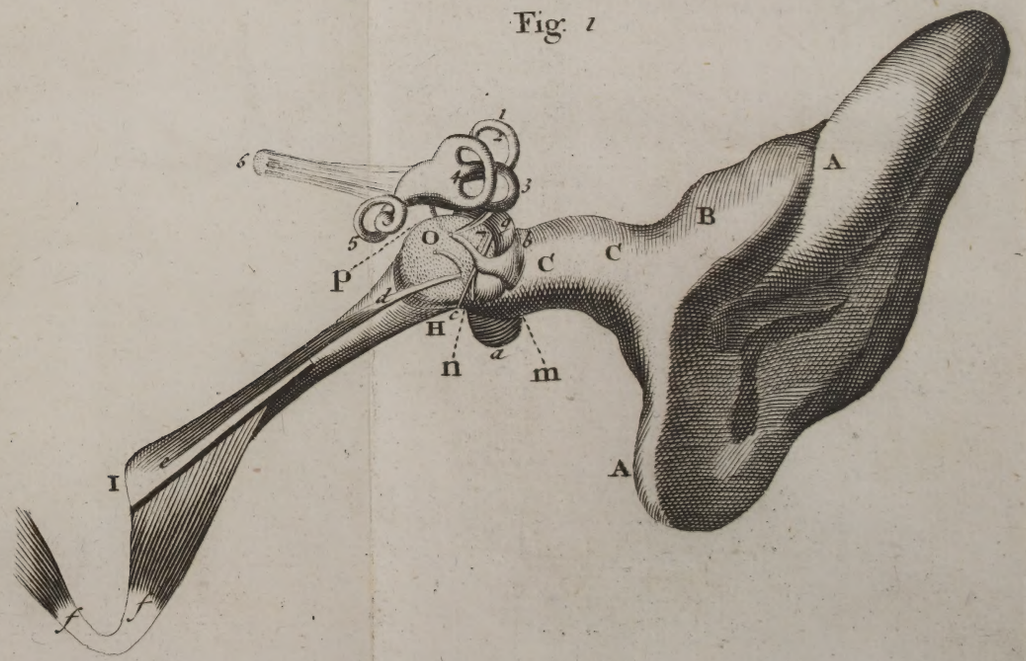


Fig. 1



SECT. XXIV. *The Auditory Nerve produces the like Effect.*

Fourthly, WE find the aforementioned Monsieur *Vieussens*, discoursing about the Auditory Nerves in the following Manner; *These Auditory Nerves rise close to the Root of the Eighth or Wandring Pair, with which the softer Branch of the said Nerves runs along; whereby it comes to pass, that there is such a great Sympathy between the Ear and the Bowels, which are provided with this Eighth Pair, that according to the Variety of the Sounds, various Motions are produced not only in the Brain, but likewise in the Breast, and oftentimes in the whole Body, and thereby* (viz. *on occasion of these Motions*) *various Notions and Conceptions are excited in the Soul.*

Besides all this, it is likewise found that the harder Auditory Nerve is likewise inserted in the Eighth and Fifth Pair, and also sends a Branch to the *Dura-Mater*, besides those which it gives to the Instruments of Hearing. See *Vieussens*, *p.* 340, and 341.

SECT. XXV. *The Motion of the* Chorda Tympani *does likewise excite the Passions.*

FROM all which it is therefore plain, that by the Motion of the Fifth Pair, and by that of the Auditory Nerve, our Passions are excited; and that the Fifth Pair produces this Effect both from itself, as it sends several Branches to the *Dura-Mater*, and a great many to the Eighth Pair, which Eighth Pair does likewise excite the Passions: The Auditory Nerve also has the same Effect, because it is inserted in the Fifth and Eighth Pair, and in the said *Dura-Mater*.

Now forasmuch as it has been already shewn that the Membrane of the Drum, which is moved by every Sound, can undergo no Motion unless the Auditory Bones, and by them the *Chorda Tympani* EO (*Tab.* XI. *Fig.* 3 and *c.* 7. *Tab.* XII. *Fig.* 1.) be moved at the same time; and forasmuch as *Du Verney* and *Valsalva* have both proved that this is a Branch lying between the Fifth Pair and the hard Auditory Nerve, and inserted in both; it follows, that this *Chorda* being always moved by Sounds, both these Nerves must likewise share in the same Motion: Wherefore it is manifest, that the Operation of this *Chorda* does likewise, among other things, consist herein, to bring the Body into Emotions or Passions of Mind by these Nerves, or at least to dispose and prepare it for the same.

SECT. XXVI. *Why the Hearing, above all other Senses, is best adapted to these Purposes.*

THE *Sight* is commonly esteemed the most excellent of all the Senses; and Experience itself has made it a Proverb, That one Witness, who has seen a thing, is more to be credited than ten that have heard it; which may be the reason, perhaps, that the *Hearing* may be adapted by its Structure, even beyond the *Sight*, to stir up Passions and Emotions in Humane Minds.

But considering that the Great GOD, according to his endless Wisdom and Mercy, has thought fit to propagate Saving Faith in his adoreable Son by the means of *Hearing*, as well before he took upon him Humane Nature, as par-

ticularly after that he left this World and enter'd into his Glory: It seemed to me (if one may presume to say any thing of the Wise Designs of the Almighty, when they are not fully revealed to us) for these Reasons, that the Instruments of Hearing have received such a different Contexture from those of all the other Senses. For in order to adapt them for so unconceivably a great Work, the following Properties are necessary thereto.

First, That the Hearing, among all the Senses, should have the Faculty to represent to the Mind absent Things, either future or past, by the means of the Sound of Words, and to make us comprehend them as if they were present; whereas the Sight, and other Senses, are only affected by Objects that are present to them.

Secondly, That the Instruments belonging to the Sense of Hearing, have moreover such a particular Structure, whereby they are enabled to excite all our Passions and Inclinations, and to awake the Powers of our Minds.

The first Property is proved by Experience; the second has been already shewn by the Description we have given of the *Chorda Tympani*, and the other Instruments of Hearing, to which might perhaps be added, as another Cause, *First*, that the Membrane of the Drum itself consists of the Union of two other Membranes, one of which is the Skin of the Auditory Tube, and the other a Part of the *Dura-Mater* which extends itself thereto. *Secondly*, that the Air which is put into Motion by Sound, can immediately affect the *Dura-Mater* by the little Holes in the Cavity of the Drum, and by the Tube which is continued from thence to the Palate. These Discoveries we owe to *Valsalva*. But this we leave to the further Considerations of the Learned: Let it suffice here, that it has been plainly enough proved, that those Instruments that belong to the Sense of Hearing, are adapted to excite the Passions.

Sect. XXVII. *An Experiment to shew the Force of Musick.*

In the *History of the Royal Academy in* France, *for the Year* 1717. (under the Head of *Observations upon Physicks in General*) we find a Relation of a great Musician, and in the *Hist.* of 1708. of a Dancing-Master; the first of whom was taken with a continued Feaver and great Ravings; and the last with a very violent Feaver, attended with a kind of Lethargy, and afterwards with Madness; and that both of 'em were perfectly restored to their Senses by Musick.

We also find several Observations made upon Persons that have been stung by a *Tarantula*, a Creature found in *Italy*, of the Shape and Size of a great Spider, which has produced the extreamest Disorders in their Understanding, Motions and Powers of Life; the Faces of some turning black, their Feet and Hands as if they were Dead; others lying Speechless, or in deep Melancholy, seeking Solitary and Burying Places; sometimes digging Pits and Holes, which they fill with Water, and wallow in the Mud thereof like Swine; finally, after having undergone innumerable Miseries, their Distempers have only ended with their Lives.

I shall not enquire into the Causes thereof; but we are taught by Experience, that this Great Evil, for which hitherto no other Medicine is known, can only be cured by the Sound of Musick, of which different Aires and Tunes

Tunes muſt be played, according to the different Nature and Colour of thoſe *Tarantula's* that have given the Wounds.

They that deſire a fuller Information of theſe Matters, may be pleaſed to conſult what Signior *Baglivi* has ſaid about it.

Whilſt I was writing this, a certain Learned Gentleman, and a Great Maſter in Muſick, did me the Honour of a Viſit; and as our Diſcourſe occaſionally fell upon this Subject, was pleaſed to inform me that the famous *Italian* Muſician, *Angelo Vitali*, had related to him the following Story, and aſſured him of the Truth of it: Namely, that a certain Player upon the Lute at *Venice* had boaſted, that by his playing he could deprive the Hearers of the uſe of their Underſtanding; whereupon he was ſent for by the *Doge*, who was a Lover of Muſick, and commanded to put his Art in Practice before him; where, after having played ſometime very finely, and to the amazement of the Hearers, he at laſt began a Mournful Tune, with a Deſign, as far as he was able, to put the *Doge* into a Melancholy Humour, and preſently after, he ſtruck up a Jovial one, to diſpoſe him to Mirth and Dancing; and after having repeated thoſe two kind of Tunes ſeveral times by turns, he was order'd by the *Doge*, who ſeemed to be no longer able to endure thoſe different Emotions which he felt in his Soul, to forbear Playing any longer.

Now that ſuch ſudden Variations in Tunes, by which Men are in one Minute's time render'd very Sorrowful, and the next no leſs Merry, do produce ſtrange Effects upon our Minds, may eaſily be conceived by thoſe that have ever felt the Power of Muſick from an able Hand: At leaſt, it is very plain from hence, and from numberleſs other inſtances, how much the Senſe of Hearing contributes towards exciting the Paſſions.

Sect. XXVIII. *The Force of other Sounds.*

However, let no Body think that nothing but good Muſick is capable of exciting Paſſions and Diſorders in the Minds of Men, ſince we have ſeen the like Effects produced by other Sounds. Every Body can furniſh Inſtances of the extraordinary Emotions and Paſſions which the Noiſe of a Drum, and the Diſcharge of Guns, do excite in the Souls of thoſe that have been in Sieges or Engagements by Sea or Land.

Phyſicians likewiſe meet with many ſuch Inſtances in their Practice. Thus we ſee Women that are troubled with Hyſterical Fits, oftentimes upon the ſhutting of a Door, the falling of a Book, or any other unexpected Sound, very much diſturb'd and frighten'd, ſo as to ſtart or leap at it.

I have met with ſome, that being troubled with this grievous Diſtemper, are not only in a continual Fright, but complain very often, that they fancy they hear the common Voices of Men, juſt as if they were the ſhrill Sounds of a Great Bell continually ringing in their Ears, which made them ready to faint.

CONTEMPLATION XIV.

Of the Senses of Tasting, Smelling and Feeling.

Sect. I. *Of the Necessity of the Tast.*

NOW as the Great Creator is wonderfully Wise and Gracious in adapting us to the Senses of Seeing and Hearing, He is not less so in the Manner by which he makes our Meat and Drink, the two necessary Supports of a decaying Life, so agreeable to us.

It seems very unreasonable and improbable, that any Body should be negligent in the seasonable Use of Food; but, unless it had also pleased the Goodness and Loving Kindness of our adoreable Creator, to bestow upon us the Sense of *Tasting*, and thereby to render the Trouble of Eating and Drinking grateful and pleasing to us, there seemed a Danger that many People would have consider'd it as a Burden and Slavery, and would therefore have often let it alone, at least, they would not have used it in due Time or Quantity. And this will not appear strange to any Body that has ever observed with how much Aversion, and many times with Loathing too, we are brought to the use of Medicines, which, with respect to the necessity of 'em, do far exceed Food itself.

Sect. II. *The Seat of Tasting is in the Mouth.*

Now can any Man think that it happen'd without the Wisdom of the Creator, that the Sense of Tasting should be just placed in the Mouth, in which all Food is at first received, masticated, or made small by Chewing, and moisten'd with Spittle, and no where else?

Sect. III. *Several Notions about the Instrument of Tasting.*

But in how great Darkness the Ancients were, with respect to the true Instruments by which this Sense of Tasting is performed in us, and how doubtfully and variously even the Modern Enquirers have writ concerning them, may be learned from the Letter of *Malpighi de Linguâ*; some placing the true Instrument of Tast in the upper Membrane of the Tongue; others in the spungy Membrane thereof; others again in the Nerves that are spread throughout the whole Tongue; some in the Almond-Glands, and their extended Membranes; others in the Throat; a few in the Pallate, which last have been entirely confuted a few Years ago, by the Learned *Bohnius, Circul. Anat.* p. 375. At present most People place them in those little Protuberances, which they call the *Papillæ* or *Nipples.*

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SECT. IV. *The Instruments of Taſt.*

WE ſhall not let ourſelves farther into this Matter, which perhaps may be hereafter cleared up by more Experiments, but only ſay, that the laſt of the above-mention'd Opinions is eſteemed the trueſt, by the greateſt Enquirers into Nature among the Moderns. We ſee then, that the Structure of the little Nipples appear peculiar in the Tongue above other Parts, and that they have ſuch a ſingular Form, as ſeems to be required for one of the external Senſes: ſince it is probable, that in the Tegument of the Tongue, theſe Orifices were expreſly made in order to admit into them the Particles of Food moiſten'd by the Glands, and to convey them to the *Papillæ* that lye thereunder, whereby they are affected with that Senſation which we call *Taſt.*

For which purpoſe the accurate Diſſections of the above-mention'd *Malpighi* and others, have ſhewn, that the Nerves of the Fifth and the Ninth Pair, which are held to be the Nerves of Taſting, are inſerted in theſe *Papillæ* after a particular manner, and ſeem chiefly to form this whole Nerve and Papillous Body; accordingly (as it is likewiſe obſerved by the ſame *Malpighi de Linguâ*, p. 16.) we find, that the Nerves that are adapted to one of the external Senſes, are at laſt dilated into a flat and membranous Body.

SECT. V, and VI. *Experiments to ſhew that the Taſt is in the Palate.*

THE famous Enquirer into the Secrets of Nature, *Malpighi*, has diſcover'd *Papillæ*, or Nipples, in the Palate, or Roof of the Mouth, and in the Cheeks alſo; ſo that according to his Hypotheſis, the Palate being likewiſe provided with the true Inſtruments of Taſt, muſt neceſſarily have that Senſation alſo.

To this we may add, that the later Writings of the Profeſſors *Bergerus* and *Hoffmann*, publiſhed ſince the Year 1700. do alſo poſitively aſcribe the Taſt to the Palate, affirming, that *Pliny* in his Natural Hiſtory has done the ſame; but they are particularly induced thereto by the afore-mentioned Obſervations of *Malpighi*; and farther, by the Account we have in the third Year of the *German Ephimerides*, of a Child of about 8 or 9 Years old, in lower *Poictou*, who in the Small-Pox loſt his whole Tongue by a Gangreen, and ſpit it out by Piece-meals; inſomuch, that at laſt there did not remain any Sign that he had a Tongue. Notwithſtanding which, this Child did not only Speak, Spit, Chew and Swallow his Victuals, but could likewiſe Taſt, by the remaining Structure of his Mouth; and (as the Author, who was a Surgeon of *Saumur*, ſays, *ch.* 8.) he could diſtinguiſh all kinds of Taſts very well; from whence the Writer farther infers from *Pliny*, that the Taſt muſt alſo belong to the Palate.

But ſince this is a thing in which Experience, as in all others, ought to be the Judge, and as the tryal hereof may be eaſily made; Let a Man only take a little powder'd Sugar, Syrup, or any other Sweet Matter, and lay it upon the Tongue; and as ſoon as ever they are melted, he will begin to Taſt; probably, becauſe they then begin to penetrate and ſink into the Orifices of the upper Tegument of the Tongue, with the moiſture of the Spittle, and ſo irritate the Nervous *Papillæ* that lye under the ſame.

But

But if he proceed farther, and endeavour to swallow the sweet Matter when 'tis melted, and to that End, presses it with the Tongue against the hinder Part of the Palate, he will plainly find, that that Part is likewise affected with the Sweetness; and especially, if after such Swallowing, he presently draws the Tongue back again to the Palate, keeping it down in such a manner that it cannot touch the same, he will find, that when afterwards the Taste of the Sugar does act upon the Tongue a little more sensibly, the Palate will be also more sensibly affected with it for a time. From whence, at least, of how little moment soever this Experiment is, all those disagreeing Notions seem to be overthrown, and the Opinion, that the Sense of Tasting is likewise in the Palate, is established upon them.

Sect. VII. *The Instruments of Smelling.*

Now to pass on to the Sense of Smelling; Can any one without acknowledging the Wisdom and Goodness of God, observe, that whereas the Bone of the Head is otherwise so hard, the Nerves of Smelling have a Bone to themselves, which, in order to afford them a Passage, is full of little Holes like a Sieve, and which is therefore called the *Spongy* or *Sieve-like* Bone; thro' which the said Nerves transmit their little Threads and Branches (being there encompassed by the *Dura-Mater)* to the Papillous Membrane or Flesh, as some call it, which lines the Cavities that are in this Spongy-Bone, and in the Top of the Nostrils, and which Nerves are expanded therein, in order probably to compose the Instrument of Smelling? For that this Instrument, which produces Smelling, is not below, but at the Top of the Nostrils, appears from hence; that in order to Smell, a drawing-in of the Breath is necessary, whereby the Particles of the Olfactory Matter being mingled with Air, must strike with some Force against the Papillous Tegument, to produce the Sense of Smelling: And every one that holds his Breath, tho' never so little, can easily Experience, that tho' any Smell be brought under his Nose, yet he is not affected with it, till he draws in his Breath again.

This Experiment seemed indeed too trifling and too well known to be mention'd here; were it not that a certain Learned and Ingenious Author had denied the same. From whence again, as above, in the Business of Tasting, the Weakness of all that is Humane does but too easily appear.

Sect. VIII. *Convictions from the foregoing Observations.*

Now, can any one that is endued with Reason deny the wise Dispositions of these Instruments, namely, that since the Olfactory Particles are convey'd by the Air, the Instruments of Smelling are to be found exactly in the Place thro' which the Air continually passes and repasses on the account of Respiration? That they are placed just over the Mouth to communicate to us, at the first, by this Sense of Smelling, some Knowledge of the Qualities of Meat and Drink which we are about to use? That the Nostrils are broader at the Bottom, that they may receive so much more of the Olfactory Particles; but narrower at the Top, to the End, that by the Compression of those Particles, the Olfactory Membrane and Nerves may be the more powerfully affected therewith?

Sect.

Sect. IX. *The Sense of Feeling.*

Besides the foregoing Senses, the Instruments of which are all disposed in their proper Places, there it one more, which is called the *Feeling*, which is in a manner distributed throughout the whole Body, especially, if we understand thereby the Sensation of Pain: But if we do not extend it any farther than to that Power or Faculty by which, when we touch any Bodies without us, we are enabled to discover the Roughness or Smoothness, the Solidity or Fluidity, and other Qualities thereof, we can only then suppose the Seat of this Sense to be in the Skin. Accordingly, we know that this latter is distinguished in the Latin Tongue by the Word *Tactus*, or Touching; and that when we would mention the Sensation of Pain, we express it by the Word *Sensus*, and not *Tactus Doloris*.

Sect. X. *The Instruments of Feeling.*

Now that this last, that is to say the Touch, is only seated in the Skin, which is naked and exposed to the Objects that are without us, is sufficiently known to the Modern Anatomists; as also, that there is in the Skin a Disposition and Contexture analogous to that of the Tongue, which the diligent *Malpighi* and others, find to consist (besides the Blood and other Vessels) of Glands, each of which has a little Receptacle or Hole that is open externally, and affords a Passage to the Sweat and Perspiration: From whence it comes, that there arise outwardly from the said Skin little Pyramidal Protuberances, like Nipples, which are encompassed and fasten'd together by a Reti-formous Body, lying between the *Cutis* and the *Cuticula*.

These *Papillæ*, or Nipples, are what have been of late Years, and with great Appearance of Truth, accounted the Instruments of Feeling, because the Microscopes seem to inform us that they spring from the Nerves, the Branches of which are inserted very thick in the Skin, and are more numerous in Proportion, than those that run to the Muscles or any other Parts, as the great Describer of Nerves, *Vieussens*, has shewn in his Preface concerning them. It is likewise plain from hence, by the help of the Microscope, that these Papillous Protuberances make the upper Skin rise in many Places, to the End, that it may be so much the more easily affected by the Contract of External Bodies.

Sect. XI. *Convictions from the foregoing Observations.*

How useful now this Sense of Feeling is to Mankind in numberless Cases, is sufficiently known; and the more, because every one that wants it, is in many Accidents disabled from preventing his Ruin; as has been found in one, who having lost the Sense of Feeling, together with Motion, on one side of the Body, and setting too close to the Fire, was miserably Burnt before he was in the least aware of it. Can then an *Atheist* say, that he is not bound to be very thankful for so great a Benefit as this Faculty is, whereby he is immediately made sensible of any violent Heat, and consequently enabled to avoid the same and many other Inconveniencies? Or will he say, that

it is a simple and ignorant Cause that has bestowed this Sense of Feeling not only upon one Man, but likewise upon all, and fixed it not in one only, but in all the Parts of the external Skin.

SECT. XII. *The Fingers and Palms of the Hand have a more acute Sense of Feeling than other Parts of the Body.*

IS it without Design, that in those Parts in which we explore and feel external Objects, this Sense is much more fine and tender than in those which we seldom use for that Purpose; for it is known to every one, that a Man feels more accurately with the Hollow or Palm of the Hand, or the Tips or extream Parts of the Fingers, than in most other Places?

And this is one of those Reasons from whence it is inferr'd, that this Papillous Body which lies between the Skin and the upper Membrane, is the real Instrument of Feeling: Since it appears by Experience (according to the Testimony of *Malpighi*, and after him of *Bohnius*, *Bergerus*, and others) that in those Places, namely, the Palm of the Hand and the Tops of the Fingers, which above other Parts are particularly useful in Feeling, there is likewise a greater Collection of these *Papillæ*, or Protuberances, than in the other Parts of the Body, which are not so frequently used for that purpose. It is likewise observed by *Bergerus*, that these *Papillæ* are much more numerous, as well as large, at the Tip of the Tongue, and in the Lips; and that these Parts do feel more accurately, as it is necessary they should, to the end, that they may immediately discover when the Food is too warm or prejudicial any other ways.

SECT. XIII. *Convictions from what has been said above, concerning all the External Senses.*

WE do now here intreat all such as still seem to doubt of the Wisdom, Goodness and Power of their Great Creator, yea, even the most unfortunate and obdurate Atheists, in case they can or will receive any kind of Instruction, that they would seriously consider with us this wonderful Disposition and Structure of the Senses, and the vast Advantages accruing thereby, not only to one, but even to all Men who are in Health: And then let 'em say, whether they can still maintain with a good Conscience, that the Greatness and Goodness of Him that formed them, does not shine out as brightly, yea, and more too in all these things, than the Skill of an Artificer in the Construction of any curious Machine.

When he considers that the Smell and the Taste do likewise serve to inform us not only of the good and bad Qualities of our Food, but that the Pleasure which we find thereby excited in us, is an Inducement to undergo this daily and continual Labour and Trouble of Eating and Drinking; will he say, that this happens by Chance, and that he is not at all indebted to Providence for all this? that is to say, for such noble Exhalations and Perfumes that proceed from so many Plants, Herbs, Flowers, Gums, Spices and other Things; for such a variety of agreeable Tastes, which he daily enjoys

from all those Eatables and Drinkables that serve for Food and Refreshment to us.

When he sees that several Parts belonging to our Bodies, such as Bones, Nails, Hair, Teeth, so far as they are naked, have no Sensation in them, and yet our whole Body is encompass'd externally with a Covering and Skin which has the Faculty of making known to, and informing us of every thing that does sensibly approach and touch it. Can he think such a Structure as this is brought about without any wise Design, and will not any intelligent Person think it unconceivable?

When he considers, that the great Wonder of the Sight enables him to contemplate the Sun, the Moon, and even those Stars that are at an unconceivable Distance from him; and that this Sense is adapted to an Enquiry into the Magnitude and Motion of such glorious Creatures, and to remark their Laws and Properties; that this Sense of Seeing can impart to him the Knowledge of many things that are out of the Reach of all the other Senses; that its Instruments are of so wonderful a Structure as has been already shewn: That to the end, that nothing may be wanting to render this Sense compleatly useful, the incommensurable Space of the Heavens is every where filled with Light: And particularly, that this Sensation should not be produced in Men without Pleasure and Agreeableness, the unconceivable Number of Rays of Light is divided into so many Kinds, either of Figure or Motion, to represent to us all visible Objects with the most pleasing Colours, Can he still fancy, that there is no Design or Contrivance in all this; and that such a wonderful Order and Regularity of every thing, with respect to each other, whereby the Light is thus adapted to the Eye, and the Eye to the Light, are all of 'em the Result of Causes working together without Order, and without Understanding? Let him once again ask himself these Questions in his most serious Retirement.

The rather, if he observes, that the Hearing informs us of the Motion and Percussion of Bodies; of which we oftentimes can get no Knowledge by other Senses; no, not even by the Sight: That therefore, since the Light does only cause us to see such Objects as are before us, the Rays of it only moving in right Lines; the Hearing warns us of things that are round about us, and such as are sometimes even concealed from the Sight, because Sounds pass thro' all imaginable Curvities.

Without this Sense of Hearing, how great would the Trouble be in communicating our Thoughts to each other? What Inconveniencies would occur to every one in Learning of Arts and Sciences, in Trade, in Pleading, and other Worldly Affairs?

Now let one of the most conceited Philosophers, one of the most *Strong Minds*, in his own Opinion, or rather one of the most to be lamented Atheists, tell us here, in case he had always wanted one of his Senses, for instance, that of the Sight, whether by the Help of all his Philosophy, he could ever have known or learned what a sort of Sensation that was, or how Men are affected with that which we call *Seeing*.

Let him make known to us, since the bodily Instruments of all our Senses are all equally produced by, and do consist of the same Bread, Water, and other kinds of Food; how it comes to pass, that his Hand has not the Faculty of seeing as well as his Eye; that his Foot does not hear as well as Ear, altho' the Light and the Air may be made to fall upon those Parts in the same Figure and Motion. Can any one think, that their different Forms produce such Sensations? Let him then shew us how they do it: Let him examine his Meat and Drink after all imaginable Ways, and tell us the Reason, why the same Bread in the Ears becomes an Instrument of Hearing, in the Tongue of Tasting, in the Nose of Smelling, and in the Skin or Feeling: He must resolve it all into the absolute Will of that adorable Creator, who is unfathomable in these his Ways, and who communicates to our Souls the Knowledge of these things in so wonderful a Manner. He must therefore be stark Blind that does not discover GOD in all these Senses.

Is there no Design or End to be observed in all this? Let then an unhappy Atheist tell us, if he had a mind to make himself or any other Person happy, and had the Power to do it, whether he would not endow them with every one of the Faculties that are found in these Senses: And in case he could have produced any thing like them, tho' in a much lower degree of Perfection by his Skill and Ingenuity, whether he would not think it a very great wrong done to him, if some Body, judging of his Performance, should not, or would not see the Wisdom and Contrivance of the Maker therein. And can he still remain insensible of his own Blindness, who declines to acknowledge the same in so astonishing a Machine, as that of humane Bodies? The rather, whilst he perceives, that in order to render all our Senses compleat and perfect, *Air*, *Light*, *Plants*, *Living Creatures*, and the whole *Universe* almost, must contribute thereto.

If then the Contemplation of all this cannot induce him to acknowledge his Maker's Goodness, and his own Obligations on these Accounts, with the utmost Gratitude; let him but consider with himself, in what a deplorable Condition he would find himself and every thing besides, if Mankind were deprived of these Effects of their Creator's Favour, which appear in all their Senses: And let him for once suppose, that there was a Man who having none of these External Senses, did neither *See*, *Hear*, *Smell*, *Taste*, or *Feel*. Now, tho' a Man were always to live thus, even in good Health, could he sufficiently express the Miseries of such a State? He that rightly weighs it, would he not rather wish to be dead, or to have never been born, or even to have been a Stock or Stone, than which he is but little better in such a State? Now if without this Mercy of God, the Misery of every particular Person would have been so great; to what shall we compare that of the vast Number of Men, who together make up all the Nations of the Earth, in case there were to be found upon it no other Creatures, but *Blind*, *Deaf*, *Insensible*, &c.

Have we then bestowed upon ourselves these Perfections of the Senses? No, certainly: Has then mere Chance been able to do it? By no means: For Chance is disposed to operate as well one way as another; and yet we find,

that

that far the greater Part, yea, all sound People, are born with all these Senses.

Let therefore a miserable Atheist confess, that he is not only ignorant, but that he must likewise for ever remain so, of the manner in which our Senses are produced, and do operate in us. All of them consist in a Motion and Impression that external Objects make upon us; all of them consist of a Motion and Passion of some of the Parts of our Body; all of them consist of Instruments produced by the same Meat and Drink; and, according to the best Philosophy, nothing else but a Motion of the same Matter can be understood to result from such a System of Matter.

Whence then proceed the various Conceptions which we find in ourselves, upon *Seeing*, *Hearing*, *Tasting*, *Smelling*, and *Feeling*? Must not then the Atheist, since there can be no other Subterfuge, acknowledge here, that there is something immaterial in us, which is the Cause thereof? Let it be so: But if it be incorporeal, how can it be moved by something that is corporeal? For there is nothing but Bodies and Motions, both in the Matters round about us, and in the Instruments themselves of our Senses: Will he say then, that a Soul cannot be moved because it is incorporeal? How then does it happen, that a Substance, which can neither be moved, nor touched by Bodies, is yet affected by or through the Motions of Bodies; and can *See*, *Hear*, *Tast*, *Smell*, or *Feel*? For that it is so in Fact, cannot be denied.

I think we need not use any farther Arguments to drive an Atheist into a Confession of his total Ignorance. And if he does not know how all these things come to pass, as his own Conscience must convince him that he does not, how can he, if he would be taken but for a tolerably wise Man, pretend to maintain it for a Truth, that a Thing, which he does not know how it happens, can be produced by the necessary and ignorant Laws of Nature; Let him reflect upon all these things most seriously with himself, before he proceeds any farther.

But if all that we have already said concerning the Senses, be not sufficient to convince him; let us go one Step farther, and shew, that even the Bounds themselves, within which the Extent of the Power of our outward Senses is confined, do likewise contribute to make us more happy, than if they could be extended a great deal farther, as in this last Age they are found to do, by the help of artificial Instruments.

Let us suppose, that our Eyes had the Faculty of our modern Microscopes; it is true, that they would shew us a World of new Creatures; a Drop of Pepper-water, or Vinegar, and the seminal Matter of Creatures, would appear like Ponds or Rivers full of Fish; the Scum of stinking and putrified Liquors, like a Field full of Flowers and Plants; the Mites in Cheese, like great hairy Spiders, and a thousand other things in like Proportion; but it may be also no less easily conceived, what a loathing of many Things, which in themselves are otherwise very good and useful, these Swarms of Insects would produce in us, which perhaps would be more evident, if you had seen as I have, how some People viewing the Mites in a piece of Cheese thro' a Microscope, and upon one of these exceeding small Creatures

falling off, suddenly snatch'd away their Hands, for fear it should fall upon them, which, by reason of the Smallness of the Creature, excited a general Laughter in some of the Standers by; but in others, more grave Reflections on account of the Wisdom of God, who has been pleased to conceal these things from the naked Eye of ignorant and fearful People: And yet to bless the Discoveries of Men by the Inventions of new Glasses, so far, that the necessary Means should not be wanting to such as endeavour to look into these Wonders.

Moreover, would these Philosophers even dare to desire, that their own Eyes should be endowed with the Qualities of the best Microscopes in case they understood the Nature and Foundation thereof? And would they judge themselves more happy, by seeing an Object so small in itself, magnified to so large a Size? When in the mean time all that their Sight could extend itself to, would be contained within more narrow Bounds than that of a Grain of Sand; nor would they be able to see any Objects plainly and distinctly, but such as were at no farther Distance from their Eyes, than one or two Inches: And as for all other things that were more remote, such as Men, Beasts, Trees, and Plants, to say nothing of the Sun, Moon, and Stars, those sublime Creatures, they would either be entirely invisible to them, or would appear at least very confusedly; yea, if all this were so, and that the natural Sight could penetrate as far as the finest Microscopes, none that have ever experienced the same can deny, but that, by the Help of them, one may see Bodies compounded of a thousand little Particles; and consequently, that in order to see every thing truly, and in its Original or last Parts, the Sight must be still extended unconceivably farther than such Microscopes have yet been able to carry it.

Now, on the other hand, suppose our natural Eyes to be great Telescopes, like those that have enabled us to observe so many new Stars in the Heavens, and make so many new Discoveries in the Sun, Moon, and Stars; they would be again liable to this Inconvenience, that they would be of very little use in seeing the Objects that surround us, as they would likewise not a little obstruct the Contemplation of all other Objects upon the Earth, because they would see too much of the Vapours and Exhalations continually arising from the Ground, which, like great thick Clouds, would hide every other visible Matter; as is but too well known to such as use these Instruments.

Thus likewise, if the Sense of *Smelling* should be as acute and nice in Men, as it seems to be in some kinds of Hunting-Dogs; no Person, no Creature, could ever meet us; nor could we pass by any Footsteps of them without being strongly affected with the *Effluvia* that proceeds from them; and we should be forced to turn our Attention, tho' never so much against our Wills; and tho' we ought to apply it to more exalted Objects, I say, we should be compelled to fix it upon these contemptible Matters.

In case the *Tongue* should make us taste Food of the lowest Savour with, as high a Sensation as now the strongest and finest *Ragouts*, or made Dishes do produce; there need no farther Proof to induce every one to confess, that this

this alone would suffice to render such Food very disagreeable to us, after having used it but a few times.

Could the *Hearing* so nicely observe all its Sounds, as it is now found to do, when, by the help of the long Tube, or Speaking Trumpet held to the Ear, any Body whispers softly into the broad End of it; how little Attention would People have for some Things? Certainly no more than we have when we find ourselves in the midst of confused Noise and Bawling of a great many Voices, or the loud Peals of Drums and Guns. They that have ever been witness of the Inconveniencies that sick People undergo by hearing too acutely, will easily be convinced of this Truth.

If the *Feeling* were so tender and nice in all the Parts of the Body, as we find it in the most sensible Places, and in the Membranes of the Eyes; must we not own that we should be very unhappy, and suffer a great deal of Pain too, by the touch of the lightest Feather?

To conclude; can any Body reflect upon all this, without acknowledging therein the Goodness of his Maker, who has not only furnished him with such noble Perfections, as are the external Senses, for want of which, he would not be better than a Stock; but who has likewise out of his adorable Wisdom, included these Powers within such Bounds, without which they would have been no other than burdensome to us, and a perpetual Obstruction in the attentive Contemplation of greater Matters?

If it should appear to some, that we have dwelt longer upon this Subject than is perhaps agreeable to 'em; let them be pleased to remember, that our principal Design throughout this whole Work, is, to represent to *Infidels* and *Atheists*, the Wisdom and Goodness of their Creator, which shines out so brightly in the external Senses of Men, and the unconceivable Faculties, or Properties thereof.

CONTEMPLATION XV.

Of the Union of the Soul and Body: Of the Imagination and Memory.

SECT. I. *The Union of the Soul and Body unknown to us: Convictions from hence.*

NOW since each of these external Senses do lead us up to the Soul; can there likewise be any Person so unhappy, as truly to reflect upon this Wonder, surpassing the Conception of all the Philosophers, this most astonishing Manner, after which the Body is united to the Soul, without being thereby convinced of the unexpressible Power and Wisdom of Him that made 'em? Of Him, who has shewn himself in this, as well as in many other things, after

ter a glorious Manner, both wonderful and adorable; who, whilst He thus Works in Ways unfathomable by all Men, does likewise compel even his Enemies to be Witnesses thereof.

And tho' others may think that they can form any Notions thereof; yet an Atheist must confess, that there is something in it which is perfectly unintelligible to him.

For suppose he should boldly maintain, that the corporeal Matter (in which, however, he can shew us nothing but Motion) has the Property of Thinking and Understanding; let him tell us, and shew us, what Composition of Parts, what Force, what Swiftness, what Limits and Directions of Course, either according to right or crooked Lines, are required in Matter thus moved, to render it capable of reasoning and comprehending a mathematical Demonstration. And we shall not need to ask him, whether this surpasses his Understanding.

Or, suppose also, that he should, according to Reason and Experience, affirm, that his Soul is incorporeal; let him shew us, how it comes to pass, that a Soul being immaterial in its Existence, and which, according to all the Notions we are wont to form of it, can neither touch or be touched by a Body, and yet can be affected *by*, or *through*, or *according* to the Motion of the Body (for we shall not here dispute about the manner of it, that being not necessary with respect to Athiests) and *vice versâ*, the Soul can affect and move the Body, or at least administer Occasion thereto, which, for the foregoing Reasons, we need not now examine: So that by its mere Will, the Body being in good Health, the stretching out the Hand, for instance, immediately follows; and if that Hand should be burnt, the Soul immediately feels Pain. Now if all this were not as certainly known to him, as the most certain thing in the World is, forasmuch as he can be every Minute convinced thereof, by repeated Experiments, would not he be tempted to look upon so disagreeing Notions, and which have not the least Analogy to one another, as gross Falshoods and vain Conceptions of the Brain? Wherefore, whatever an Atheist may fancy to himself, the manner of the Union of the Soul and Body must always remain unconceivable and unintelligible to him.

I know very well, in case we proceed no farther, that the great Disagreement, concerning the manner in which the Body is moved by the Will, and which has occasioned many Treatises among great and wise Men, must be left undetermined by us: But neither is this the Place, nor yet the Time, to say any thing about it, since we only write for the Conviction of Atheists; whereas the others, howmuchsoever they differ in their Opinions, do all agree in the Belief of a God.

Sect. II. *The Bounds of this Union.*

This Union of the Soul and Body is not only wonderful in itself, and in the manner in which it happens, but likewise in the Bounds and Limits which are prescribed to it. We find it thus in the first Place, that *the Soul does not operate by its Will* (however it be) *upon our whole Body*; or rather, *that our whole Body is not subject to the Soul in its Motions*, but only, as it should seem, those

Parts that receive their Nerves from the *Cerebellum* and Back-Bone: Wherefore it is only our Arms, Hands, Legs, and all those Members with which we are said to act freely, that are moved according to the Pleasure of the Soul; whilst other Parts, which have their Nerves from the *Cerebrum*, and which do only serve for Life and the Support thereof, as the *Heart*, the *Arteries*, the *Stomach*, the *Bowels*, *&c.* do by no means obey the Will of the Soul, nor, like the former, can be moved or stopt at Pleasure.

Secondly, *Neither does the Soul feel when every Part of the Body is acted upon or affected.* Thus we find, that besides the *Hair* and *Nails*, the *Bones* themselves are likewise insensible; all which make up a great Part of our Body: Not to mention that the *Lungs* are known to waste away in many Men without Pain; and that the Chirurgical Observations teach us, that the Substance of the *Brain* may suffer very much, without communicating any Sensation thereof to the Soul.

Sect. III. *Convictions from thence.*

Can now a deplorable Atheist think he has so much cause to accuse the Christians of Credulity, when he hears them make the following Conclusion from the above-mentioned Premises: That since no Body can justly ascribe all this to mere Chance, working indifferently one way as well as another, this is a true and convincing Proof, that it can by no means proceed from a necessary Series of Laws of Nature, always operating after one and the same manner, that the Soul should have the aforesaid Relation or Respect to the Body: Forasmuch as the Wise Creator being desirous to convince us all, that He neither operates by Chance, nor is confined and determined by certain necessary Laws, but freely, and according to his own good Pleasure, has render'd some Parts of the Body obedient to the Will of the Soul; and caused others to move entirely independent thereupon; nevertheless, these last, as well as the first, are so far subjected to the Soul, at least related to it, that both the one and the other, so long as the Soul remains united to the Body, but no longer, are enabled to perform their Functions, and remain without Corruption.

And that Atheist that will hearken to Reason, seems particularly to be obliged to justifie a Christian in the aforesaid Conclusion, since it is just those Parts that serve for the support of our Life, such as the *Heart*, *Stomach*, and other *Entrails*, that are not only not submitted to our Will, but moved unknown to it, by the Power of the Great Creator, that he may convince us of our Dependance upon him. Whereas, on the contrary, the Motion of such Members as the *Tongue*, *Hands*, and the rest, are left to the Disposition of our Will, that they may serve to acknowledge and glorify our Great Benefactor, likewise in our Bodies, which is what He with so much Justice requires of us.

Sect. IV. *The Imagination and Memory.*

There would yet have been something still wanting to the Perfection of a humane Creature, notwithstanding this wonderful Union of the Soul and Body, if we could not have exercised the Understanding and other Faculties of our Souls upon such Objects only as are present or before us. Nor would

our

our Judgments and Inferences, or Deductions, have been of much weight, if we could not have compared preſent Things with any other paſt or future.

How ſhould we have been able, for inſtance, to have made any uſeful Diſcoveries about the Laws of the Sun's Motion, in caſe nothing thereof were known to us beſides what we could learn from things preſent? For as to thoſe that are abſent, ſuch as things paſt or to come; the external Senſes, tho' they be the firſt Helps of enquiring into all bodily Matters, cannot inform us the leaſt thereof. Even the Hearing itſelf, which ſeems otherwiſe to be in ſome meaſure adapted thereto, would yet be entirely unfit and uſeleſs to this Purpoſe, without the other Powers, of which we are now about to treat.

Our Gracious Creator, in order to multiply his Wonders upon us, and to render us compleatly happy, has been pleaſed to ſupply this Defect likewiſe, and to lodge in us a Power of repreſenting to the Underſtanding, even paſt, future, and all abſent Things. The firſt of theſe Faculties is named, by the Philoſophers, the *Memory*; the laſt, the *Imagination.*

Whether it be now that theſe owe their Origin to certain Motions of the *Spirits*, or *Humours*, or *Membranes*, produced by our external *Senſes* or *Thoughts*, and leaving behind them Traces and Footſteps in the *Brain*, which give our Souls an occaſion to think after ſuch a manner, as if the things repreſented to the Imagination or Memory, were really preſent: Or whether there be any other Cauſe thereof; this is certainly true, that the endowing Mankind with ſuch a Power, does far exceed the very wiſeſt Diſcoveries. And in caſe we were not aſſured thereof by Experience, who could believe that it was poſſible for any Man to repreſent to himſelf things having no Exiſtence, as if they were exiſting; dead things as living; and thus render an Object as preſent, which is either abſent, or even not exiſting at all?

CONTEMPLATION XVI.

Of the Humane Paſſions or Inclinations, and briefly of Procreation.

Sect. I. *The Paſſions and Inclinations.*

MAN being thus bountifully furniſhed, by the Goodneſs of his Creator, with all the above-mentioned Powers and Faculties, ſeemed to be placed upon the higheſt Degree of Happineſs. His intelligible *Soul*, united after ſo wonderful a manner to his *Body*, exerts its Conceptions and Judgment upon all Matters that occur to it; his external *Senſes* impart to him the Knowledge of material Beings; his *Imagination* and *Memory* repreſent to him every thing that is abſent, either paſt or to come; his *Heart* and *Arteries* beat; his *Bowels*, and all other Parts that are neceſſary to Life do, by the Power of his Creator, continually diſcharge their Functions, without giving him the leaſt

trouble

Trouble during the whole Course of his Life; the other Limbs and Members are obedient to his Will, enabling him to glorify his Maker with Thankfulness, and be useful to himself and his fellow Creatures.

Now this last might seem to be in some manner inconvenient to him, it being the only Motion that can occasion Trouble or Weariness to him. But to the End, that he should not faint nor be discouraged whilst he is promoting his own Happiness, or that of others, who are dear to him, it has pleased the same Gracious God, not only to enable all the Powers of Man to be concurring thereto, but which is a greater and particular Benefit, to be concurring therein with Pleasure; and accordingly, to endow him with various Inclinations and Passions to stir him up to perform, with Zeal and Eagerness, all that is necessary for him to do.

Thus we find in our selves a Desire, or *Longing*, and *Hope* for that Good which we consider as approaching to us; and *Joy*, when we have obtained it, and *Love* towards it, when we are possessed of it: And on the contrary, a *Fear* for approaching Evil; a *Sorrow* when it comes upon us; and *Hate* against the Causes that make it keep the Possession of us. Now, not to give a List of their Names here; Can any Man contrive or invent sharper Spurs to induce him to seek after that which he esteems good to himself, and those that are dear to him, and to avoid all that he thinks evil? And how strongly a Man can be excited thereby, daily Experience teaches us, as well as the deplorable Examples of those unhappy Men, who by a corrupt Judgment, embracing Good for Evil, and Evil for Good, make a wrong Use of these so necessary Passions.

Now to repeat our Question again, Can these Incitements and Allurements be lodged in us by mere Chance, or any thing that has neither Knowledge nor Understanding? Which, in order to render us more happy, do not only induce us to perform our Actions with so much Eagerness, but do likewise, upon many Occasions, and even without our Will, give the Instruments of our Motions more Life and Energy; or, have not here all reasonable Men just cause of Thankfulness for the Mercies of their Creator, who, considering us as the Master-piece of all his Works, would not suffer us to want those Powers, whereby we are enabled to promote the Welfare both of ourselves and fellow Creatures, even with Pleasure and Satisfaction.

Sect. II. *The Difference of Passions and Inclinations.*

And if any one should fancy that this Question supposed too much, in order to demonstrate, that the Wisdom and Goodness of the Creator only, and no accidental or ignorant Causes has any Place in these Passions; let him reflect upon these two or three following things only with us; from whence the Government of God, and the Execution of his wise Purposes, seem to shine out so brightly, that even an Infidel, or any other that doubts of it, if he would but use his Reason, cannot, with any Foundation, insist upon a fuller Proof thereof.

For were there no God that directed every thing according to his Providence; how comes it to pass that Men (whose Bodies and all the Hu-

mours thereof are made out of the same Food, and therefore consist of the same Matter) do yet, in cases where the Interest of humane Society requires, differ so much from one another, in their Passions and Inclinations; insomuch, that each of 'em do, with Pleasure, embrace some particular Business (with a view to their own Ease and Advantage) in order to please and profit their Fellow-Creatures?

Now since no Man's Life is long enough, nor no Body's Opportunity or Power great enough to provide every thing for himself necessary to his Support and well Being; Can we not herein discover a Providential Direction, to render Men assisting and helpful to each other in their particular Wants, that each one, out of Choice and Inclination, is driven on, even, tho' his own Gain be chiefly in view, to concur, as far as in him lies, thereto? Thus it happens in our Fancies to particular Studies; one finds himself inclined to that of Divinity; another to the Knowledge of Laws and Customs; a third to Physick; a fourth to an Enquiry into the Nature and Works of God; others, to the reading of the Transactions and Revolutions that have happen'd to the World in former Ages, in order to apply that Knowledge to prudent Conduct of Affairs in their own Time. Many again find themselves inclined to quit other Sorts of Employments; such as don't so much care for a speculative Life, take more pleasure in Trades and Merchandizing, which they likewise make Choice of according to their different Passions and Humours. Others betake themselves to the several Arts of Painting, Building, and to Manufactures, of which likewise the kinds are both different and numerous.

Can any Body now judge, that it is the Result of mere Chance, that Men, from all of whom, by reason of the Similitude of their Structure and Food, one should seem to expect nothing but an Identity of Inclinations, do discharge their Affairs and Functions so variously? And as strange as this may appear to every one at the first View, yet does not Experience teach us, that 'tis of absolute Necessity to all Mankind that it should be thus? And in case all of them were inclined to the same thing, for instance, if every Scholar should apply himself to the same Studies, every Merchant deal in the same Wares, every Artificer in the same Handicraft, there would not only be a Failure, but likewise an entire Deprivation of the Ease and Convenience of the whole World.

Sect. III. *The Agreement of the Inclinations and Passions.*

Against all this, a miserable Philosopher that apprehends nothing more than to be forced to acknowledge a Supreme Director of all Things, and consequently to meet with an undoubted Punishment for his Blasphemy and atheistical Behaviour, would endeavour to object this Subterfuge and Evasion, namely, that we are taught by Experience, that such a great Difference of Passions are innate, and brought into the World with all Men? and therefore, that they only flow from the particular Contexture of Bodies, *&c.*

But

But to convince these Persons that this, and every thing besides, is rather the effect of a wise Direction, than of mere Chance or ignorant Laws of Nature; let them go a little farther with us, and ask themselves the following Question; In case this Variety of Passions does proceed only from the Structure of Men, how comes it, that the contrary has place where the Diversity of Inclinations would be hurtful to the Publick? Why have all Men living one and the same Desire to eat their Food with Pleasure? Why are all Men, and even all other living Creatures, hurried on with the same, and sometimes ungovernable Passions, to Generation and Procreation? And lastly; Why have they the same Love to their Children?

Certainly no Body will deny that unless these Passions were found to be alike in all Men, and in case there were room here for so great a Disagreement as in the others; or, to carry on the same Comparison, if the Desire towards Food were only found in a few Persons, Food itself would be no otherwise used by many, than as a Medicine against that Death which was to be the Consequence of an unsatisfied Hunger. Now, with how much Aversion and Loathing this happens in many, even where the Distemper renders it most necessary, is sufficiently known; and from thence as easily inferr'd, that many People, abstaining too long from the use of Food, lose the Powers and Faculties of Digestion. If likewise there were as few inclinable to Generation, as we see there are, who choose the same way of Living and Employments, must it not be confessed that the World would be soon naked and dispeopled? Again, if the Love of Parents to their Children were so uncommon, as the Inclination of Men to one and the same Trade or Calling, how many poor Creatures just born, would, for want of Necessaries, meet the End of their Lives almost as soon as the Beginning?

And to conclude the whole with one word; Let an obdurate Atheist put this Question to himself, and answer if he can: Whether he does not therein discover the Wisdom of a Great Director? And whether he can, with an entire Conviction, and without being contradicted by his own Conscience, affirm, that it appears to him to be merely accidental, that there is found a Variety of Inclinations of Men, where such a Variety is useful to Mankind; and on the contrary, that the Inclinations and Passions are there only uniform where such an Uniformity is necessary; and where a Disagreement would dispeople and desolate the whole Earth? At least, let him tell us, whether, if he were to have regulated these things for the Good of the World, and with the utmost Prudence, he could have fallen upon a better Method?

Sect. IV. *The Love of our Country.*

What Necessity can be deduced from any natural and ignorant Cause, from whence it should follow, that all Men feel such an over-ruling Inclination towards the Country in which they are born? And how it is possible, that the cold, barren, northern Parts of the World, where besides, a great Part of the Winter, is nothing but a dismal Darkness, should not yet be dispeopled of their Inhabitants; or, that they should not yet have betaken themselves to the fine southern Countries, where the Air is milder, and all

the Necessaries and Refreshments of Life more plentiful, long before now; and, which is more, that many Men after having tasted the Pleasure of the latter, shall yet freely return to the former: I say, how can this be accounted for, without resolving it into the Will of the Great Director, that Men should likewise inhabit even such Parts of this Globe?

Sect. V. *The Contempt of Dangers.*

If this be not sufficient to convince our Atheist, let him consider in the last Place, whether he can, upon his Principles, account for that dreadful Thirst after Honour and Glory, which all Ages have beheld with Amazement, in the Actions of their Heroes; and which hurries Men on, and makes them run headlong into the greatest Dangers, yea, even Death itself, to which Humane Nature has the greatest Aversion.

Not to mention those whom their Wants oblige to follow the War, can any one reflect, without wondering, that Great Men and Illustrious Persons (who are otherwise in a Condition to enjoy all the Pleasure of the World in Plenty, and at least, to die an easie Death in a good Old Age) should yet expose themselves with so much Zeal and Bravery to the innumerable Dangers of War, where they daily, and by a terrible Experience, find that Lot to fall to others, which to Morrow, or perhaps sooner, may be theirs; also of being slain, or at least render'd miserable all the rest of their Lives, by their Wounds and Loss of their Limbs?

Now, to ascribe the Cause of such a noble Courage and Bravery to mere Chance, is a very ungrateful and unworthy Treatment of those great Men, whose Wisdom has not given the World less matter of Admiration than their Courage.

To deduce it from Stronger Passions, is likewise not possible, as we have already shown, because the Fear of Death, provided that they may live without Shame or Misery, is the strongest of Passions in all Men whatsoever. What Reason then can be thought of for all this, save only the Supreme Will of the Great Director of all things? who has infused into the Souls of some Men, whom his Providence has marked out for great Events, the right Principles of a true Generosity and Courage; letting them see that He has chose them out of an infinite number of other Persons, and laid this Obligation upon them of opposing Tyranny and Absolute Power, and of restoring to their own Country, and to their Friends and Allies, those dearest Blessings of Religion and Liberty, even at the hazard of their own Lives. And who again has made others, tho' they proposed to themselves no other End than the gratifying their own Inclinations, or at least, acquiring Riches and Glory; like many of the Heathens, to despise Death and Danger in a most unconceivable manner; whereby he has compelled them, tho' insensible thereof, to be subservient to his Providence and Adorable Purposes.

Sect. VI. *Convictions from the foregoing Observations.*

Let him that has hitherto doubted of God's Government, seriously reflect upon this great Wonder, and see whether he can deduce that which he

he finds true by Experience, of the Course of these Passions and Inclinations in Mankind, from an accidental Concurrence of *Nerves* or *Fibres*, or *Humours* of the *Body*; or from any Laws of a stupid Nature, unable to propose to itself the least Design in all its Works; and then tell us how it can come to pass, that upon such Principles, these Functions, so necessary and useful to humane Kind, and at the same time so wonderful too, can be so constantly discharged; and that in all Ages the same Steadiness and Uniformity has appeared therein, which can never be applied or attributed to mere Chance?

Sect. VII. *The Desire of Procreation.*

Can any Body avoid seeing from all that has been said, that the Inclinations inherent in Mens Minds, as corrupt as they be, and applied often to wrong Objects, owe their Origin to something more than Humane Wisdom? Which having thought fit to render them subservient to his great Purposes, causes them to prevail over all Obstructions: To which end, He has vouchsafed to qualifie the most Bitter things, which in their own Nature can produce nothing but Aversion and Terror, with the most desirable Charms, and to render them, as I may say, palatable, with an agreeable Sauce to incline our Passions thereto, notwithstanding all the aforesaid Impediments; and to the end, that we may put this past all doubt, let the Atheist, besides what we have just now said, about the Contempt of Dangers; let him, I say, turn his Eyes with us upon that Inclination which Men feel in themselves towards Procreation.

Now if it were not the Will of the Great Director of all Things, that the Race of Men, which would otherwise end in each Individual, and be quite extinct with the Life of one Man only, should be supported in their Posterity; How happens it that all living Creatures are hurried thereto with a Passion exceeding all others? But to proceed farther, How is it conceivable, when in the bearing and bringing forth of Children, Women do not only undergo so much Trouble and Pain, but frequently visible Danger of Death, that there should be one only to be found, that would venture the same a second time after having once made the terrible Experiment? I say, how comes all this to pass, if it had not pleased the Great Creator to confirm the Words which he spoke in the beginning of the World, *Gen.* i. 28. *Be fruitful, and multiply, and repleniſh the Earth*; and thus to support the Truth of them by a never-failing Experience. In vain do we seek for other Reasons thereof, nor can any thing seem more unreasonable than to ascribe this to Chance or ignorant Causes, especially if we weigh the following Circumstances: Can any one imagine, that it is without Design, that there should be made just two sorts of Persons, in every thing alike to each other, and different only in those Parts that are required for Generation; and that, besides these two, we know well enough, that there was never any third?

Sect.

SECT. VIII. *Why we have not treated more fully and minutely upon the Buſineſs of Generation.*

WHOEVER reads this will perhaps think it ſtrange that we have not ſpoken more largely concerning the Affair of Procreation, ſince the Providence, Wiſdom, and Power, of the Great Creator ſhines forth ſo irreſiſtably and glaringly in that whole Matter. But they may be pleaſed to know, that the ſame Reaſons that made us keep Silence, or ſpeak ſparingly upon many other of the foregoing Subjects, ſuch as the manner after which the Separation of the Humours is made, the Tumifaction or Swelling of the Muſcles, the Uſes of the external Senſes, the Limits of the ſo called *Senſorium Commune*, and many more, have induced us likewiſe to obſerve the ſame Caution here; *viz.* becauſe the Truth has not yet been confirmed by Experiments in ſo ſure a manner, but that there ſtill remains a great Variety and Difference in Opinions among the moſt learned Men concerning them.

SECT. IX. *The Principles, or* Stamina, *of Living Creatures.*

WHETHER it be then, that the firſt Principle, or *Stamen*, of Men is to be ſought for among the *Animalcula*, or among other Particles without Life indeed, but put into Motion (for thus differently are they defined by ſome of the moſt famous Enquirers into Nature) which, by the help of Microſcopes are diſcover'd *in Semine maſculino*, of all Creatures that have been hitherto examined: Whether it be to be found in the Eggs of the Females, as others pretend; or laſtly, whether it be that the Coition of both the Sexes is neceſſarily required to the Formation of this *Stamen*; all which we do not pretend to determine here: This is however ſure enough, and after ſo many Enquiries, is received by all the modern Philoſophers, that all living Creatures whatever proceed from a *Stamen* or Principle, in which the Limbs and Members of the Body are folded and wound up as it were in a Ball of Thread; which by the Operation of adventitious Matter and Humours are filled up and unfolded, till the Structure of all the Parts have the Magnitude of a full grown Body. In order to be convinced thereof, the Reader may conſult the Obſervations of the great *Harvey*, both upon Men and Beaſts, both the *Viviparous*, or ſuch as bring forth their Young alive, and the *Oviparous*, or thoſe that lay Eggs, in his Book *de Generatione Animalium*. And after him the accurate *Malpighi*, in the Experiments he makes upon the Hatching of an Egg, and the Formation of a Chicken in the Egg.

Thus we find the firſt of thoſe ſpeaking of it in his 15*th* Exercitation; *That the Stamen, to the beſt of his Knowledge, before he had obſerved it, was accounted by no Body to be the firſt Origin of the Chicken.* And *Malpighi* ſpeaks of it in the following manner: *Wherefore it muſt be owned that the Stamen of a Chicken is already in the Egg before the Hatching; and therefore muſt have proceeded from a higher Cauſe after the ſame manner, as in the Eggs of Plants.* Thus he makes an entire Analogy between the *Stamina* of Living Creatures and the Seeds of Plants: In which laſt he is likewiſe wont, for the ſame Reaſon, to mention ſome Parts by the Name of the *Uterus*, *Placenta*, and the like, which are only proper to Living Creatures.

It

It shall suffice here, to have quoted those two great Men for the Confirmation of the Truth of what has been before-mention'd, since they seem to have been the first Discoverers thereof: And since all the great Naturalists of this Age have been convinced thereby, and by their own further Experiments, that the Beginning of all Creatures consist in a *Stamen*, as may be shewn in numberless Places of their Writings, which those that please may have recourse to.

I would have been something more particular upon this Subject here, which seems to be the proper Place for handling it: But forasmuch as the Encrease and Growth of Animals from these little *Stamina*, may receive a great Light from those of Plants, which may be found in every Seed; I chuse rather to refer my Reader to *Contemplation* XXIII. where I expressly treat of that Subject; or rather to the *Observations* upon *Plants*, of those famous Philosophers Messieurs *Grew* and *Malpighi*, where he may find Experiments enough, to shew that a Plant is produced from a *Stamen*, and a living Creature from a like *Stamen*; or, to speak in their usual Language, is unfolded, as we see in a Silk-worm, where the Butterfly comes out of the *Aurelia*, in which last all the Parts of the Butterfly are involv'd or roll'd up. *See Malpighi de Bombyce.*

And since we have already an experimental Certainty, that a Male and Female Creature are necessary toward the Procreation of another of the like Species; I leave it to those that have the Opportunity of carrying their Enquiries farther, what is performed by each of 'em in particular, towards Generation; as likewise, whether in the Egg of a Female, the solid Parts of the *Stamen* of the future Creature are to be found; and whether it be impregnated and vivified by the *Semen Masculinum*, and brought into Motion agreeable to the Laws of the seminal Matter.

This seems to have acquired some Degree of Probability; forasmuch as we know that the Body of a Man does only consist of solid and fluid Parts, but is likewise endowed with certain Laws, pursuant to which all the Parts are moved; so that thereby the same Bread, which at first according to the Laws to which 'twas Subject in the Plant, was Wheat or Rye, being afterwards eaten by a Pullet, does, according to other Laws, become Pullets Flesh; and finally, this Pullet being again converted into humane Food, becomes the Flesh of a Man; and so in other Cases.

This might cause some Suspicions, whether that which is discover'd by the Help of a Microscope in *Semine Masculino* (which the accurate *Verheyen, Part.* II. *p.* 69. asserts to be Particles put in Motion, and not the *Stamina* of Living Creatures) may not be that Matter, which, according to the Laws that the Great Creator of all Things has produced in every particular Man and Beast, being put into Motion (and like Fire that kindles other Matters, or Yeast that ferments other Liquors, and moves them according to its own Laws) does propagate and maintain the Laws of the required Motions in other Substances: Whereupon the Observation of Mr. *Hartsoker*, as related by the said *Verheyen*, are very remarkable; it appearing thereby, that this mov'd Matter in *Semine Masculino*, does preserve its Motion some Hours in the Cold, but in the Heat it soon disappears. This seems better to agree with Particles

that evaporate with Warmth, than with *Animalcula*, which usually stand in need of it, and are first produced by Warmth; at least, if we suppose these Particles to be divested of Animal Life, and to be only Matter put into Motion, this absurd Consequence may be prevented, namely, that in the *Semine Masculino* of every Creature, there must be a thousand lost for one that comes to good.

Experience does likewise seem to confirm the said Hypothesis (that from the Female proceeds the Matter, and from the Male the Particles that propagate the Laws of Motion therein;) forasmuch as a Mule is produced from the Coition of a Horse and an Ass; and so in other Mixtures of different Species. The above-mention'd Mr. *Verheyen*, *p.* 71. may be consulted hereupon. But this may suffice for Probabilities, since, as far as I know, no Body has yet been able to give us an entire Decision of this Matter.

Sect. X. *Convictions from the foregoing Observations.*

Only forasmuch as it is now found to be experimentally true in almost all kinds of Plants and Living Creatures, that have been enquired into, that the former have their Origin in a Seed, and the latter in *Stamina*, but none from meer accidental Causes, as Corruption and the like, I cannot upon this occasion forbear entreating the unhappy Atheist, if any Convictions will yet satisfy him, that he would be pleased seriously to reflect on all these things by himself, and then pronounce, whether mere Chance, or other Causes, ignorant of what they did when they thus acted, could produce all these *Stamina* of Men (not to mention here the Seeds of Plants, and Eggs of other Creatures) with so much Art, and in so great a Number, and could insert and fold up all the Limbs and Joints of such a wonderful Machine, as is the Humane Body, in so nice and accurate a manner, that the same should be fill'd up and nourished by Juices, or (to use the common Technical Word) having expanded or infolded it, would bring this Body into such a Disposition and Structure as is necessary for so many great Purposes for which it is formed.

The Atheist cannot be ignorant how many Learned Men have openly acknowledged in their Writings, the Almighty Power of the Great Creator, upon enquiring into these his wonderful Works and Productions of Men, Beasts and Plants from such seeming inconsiderable and contemptible *Stamina*. Now then one of these two things must be true; either that it is a certain and undeniable Demonstration of a God, or that so many famous Men are utterly ignorant wherein the Strength of such a Proof consists, and are therefore to be accounted compleat *Visionaries* or Whimsters, if not meer Fools. This last must be asserted by the Atheist concerning most of the famous Undertakings of the late Age, or else he must abandon his unhappy Principles. Let him therefore consider with himself, for what he himself must pass, with all Rational and Equitable Persons.

SECT. XI. *Several Difficulties removed.*

NOW that a *Stamen*, which perhaps at first contained nothing more than the Quantity of a little Grain of Sand, and perhaps less, can be unfolded or expanded to the Magnitude of a Humane Body of Six Foot long, a Mathematician will freely, and even an Atheist himself, if he understands any thing of the Mathematicks, must confess. But forasmuch as others, and even some well-meaning Christians, cannot easily conceive this great Expansion of such a small *Stamen*, and may therefore think it impossible, it seems proper and useful too, to remove this Difficulty, by shewing the Possibility thereof.

Let it therefore be supposed;

I. That the Divine Power can divide a determinate Quantity of Matter (for instance, a little Grain of Sand, or any thing less) into so many Parts, and more than any Man can express by a definite Number. No Body can deny this; and even an Atheist must acknowledge, that in respect to this Grain of Sand, such a Division or Separation of Parts, does neither include a Contradiction, nor any Impossibility in itself.

II. That a Foot being divided into ten Parts, each of those Parts may contain a hundred Grains of Sand; which many other do admit with us.

III. That the Body of a Man, which is Six Foot high, may be supposed to contain in it Six Cubical Feet; which, allowing for the Cavities therein, may be a pretty just Calculation.

IV. Now since 100 Sands do compose the tenth Part of a Foot in length, which we will here call an Inch, and ten such Inches in a Foot, a thousand Sands will go to the length of one Foot; and consequently (supposing, for convenience sake, the Sands to be so many little Cubes, 1,000,000,000 or (to express this Number with more Brevity, or the Unite with nine Cyphers) 10^9 Sands do compose one Cubical Foot, which being multiplied by Six, makes the whole number of Sands, that may be contained in a Humane Body of Six Foot in length, amount to 6,000,000,000, or 60^9; from whence it appears, that in case such a Stamen, no bigger than a small Grain of Sand, were divided into 6,000,000,000, of Parts in each space of a Sand in this Body, one Particle of the said Sand might be placed.

V. Now to proceed further, since it appears from the XXVI. *Contemplation*, §. 16. of Mr. *Leeuwenhoek*, that $\frac{1}{100}$ of the length of a Sand, is the utmost that can be distinguished by a Microscope; to the end, that we may not take any Quantity that may not be justly suspected of not being distinctly visible, let us take the $\frac{1}{1000}$ of this length, so then $\frac{1}{1000000}$ of a Sand's length is incapable of being distinctly view'd by any Microscope. Since then there go 10^{18} of such Particles into the Composition of one Sand, there will be 6027 of such little Cubical Spaces in a Humane Body of Six Foot in length; but by reason of their Smallness, they will be undistinguishable, even with the best Microscopes.

Now if we suppose that in each of these small Spaces there be a Million of Parts in one Sand, there will go to the Composition of the aforemention'd Body 60^{33} of the like Particles of Sand.

VI. Now in case the *Stamen* of a Man, which we have supposed to be as big as a single Grain of Sand, were divided into so many, or into 60^{33} Parts; its Parts may be so disposed and expanded, that in each small Space of a Humane Body of Six Foot in length (which Parts, by reason of their Smallness, have not yet been able to be distinguished by the finest Microscope) there may be contained a Million of such Particles of Sand. And since the Interstices between the Particles of the *Stamen* are yet so much smaller than the aforesaid little Spaces, they will be yet less visible thro' a Microscope, and consequently almost invisible to the naked Eye; certainly in no manner distinguishable.

VII. And thus it appears to be possible that such a small *Stamen*, no bigger than a Sand, may be expanded and brought to the analogous Composition of a Humane Body of Six Foot long; which Body, in its whole Matter, did not contain more than the quantity of this single Sand, yet in such a manner, that there was not one visible Place therein so small, in which there were not contained more than a Million of Particles of this little *Stamen*: Between all which Particles, there were still remaining so many Interstices or Vacuities, that this Body, which, by reason of its Lightness, might be deemed little more than a Shadow, can be so filled with flowing and adventitious Parts, fixing themselves in these Insterstices, and cloathing as it were the Parts of this *Stamen*, that it at last attains to the Weight and Size of a Common Body of a full grown Man.

VIII. And to the end that no Body may be surprized at these minute Divisions of the quantity of a Grain of Sand, he will find in *Professor Keil's Introduction, p.* 55. something that may appear much more wonderful to him, of which, however, the the Possibility is there demonstrated; *viz.* how not only a Body of Six Foot in length, but even that unmeasurable Space, containing in its Circumference the Starry Heavens, or even a much larger, if you please, may be filled and obscured by the Dust of one single Grain of Sand, after such a manner, that not so much as a Ray of Light, tho' never so fine, shall be able to pass between the Parts of that Sand: Imagine then how far this surpasses all that we have supposed to happen in a Humane Body.

IX. To prove this by a like Experiment, we shall show in our CONTEMPLATION upon *Light*, that a Particle of the Tallow of a Candle, not exceeding the quantity of a single Grain of Sand, is really and actually divided into many more than the aforesaid 60^{33} Parts.

To demonstrate this very briefly here, you will find in the just now mention'd Contemplation, that a Cubical Inch of Candle-Tallow does emit or yield the Number of 269617040^{40} Parts of Light. Now, according to *Numb.* IV. here above, there are 1,000,000 Sands in the quantity of such a Cubical Inch, and consequently there proceed from a Particle of Tallow, of the bigness of one Sand, 269617040^{34} Parts of Light.

And

And according to *Numb.* VI. the Stamen that was likewise of the size of a Sand, was supposed to be divided into 60^{33} Parts.

By which number of the like Particles, which proceed from the quantity of a Sand, or are divided into $26961704O^{34}$ Parts, there will proceed 44936173 with a little Fraction. From whence it appears, that each little Particle of this Stamen, how small soever it may be (to take a round Number) may be still divided into 44, and very near 45 Millions of Parts, before each of them arrive to the Smallness of one of the Particles of Light, that continually flows from a Burning-Candle.

Now that these exceeding small Particles are not unnecessary, on account of their Smallness, but are made use of to great Purposes in the Universe, shall be hereafter demonstrated in our 25th *Contemplation*; as it is manifest from those of Fire, which are found every where in the visible World, and are made use of by the Great Governour thereof for such wonderful as well as terrible Ends.

And thus will it appear plain enough, as I think, that in such Expansion and Division of this *Stamen*, we do not come near to that minuteness, into which we see experimentally that other Bodies in the World may be divided.

Sect. XII. *Convictions from the foregoing Observations.*

We do not here pretend to determine the Manner that God has been pleased to make use of in the Expansion of his Created *Stamina*; we must leave that to his infinite Wisdom, whose Ways, herein especially, are inscrutable, or past finding out; nor have we had any other View in what we have said concerning it in the foregoing *Section*, than to convince the Atheists, that they had a Maker, and to set things in a somewhat clearer Light before the Eyes of such Christians that are not just accustom'd to compute these Matters after the manner of Mathematical Propositions; and therefore might find some Difficulty in expanding such a Small *Stamen* to the similar State of a full grown Body.

Let then an unhappy Philosopher, who will not yet confess an All-ruling God, from what has been said before; let him, I say, retire to some solitary place, and seriously contemplate his own Body, and then judge, whether it could possibly come to pass, without a wise Direction, that from so small and tender a *Stamen*, expanded, filled or stuffed out, and cloathed with other Matter, a Body so wonderfully formed and adapted to so many Uses in all the Limbs and Parts, has been produced. What is there in a Watch, and in the adjusting of all its Wheels, Springs, *&c.* that can be compared to the wonderful Formation of a Humane Body? And yet, was ever any Body so senseless, or, to speak in softer Terms, so deplorably unhappy, that he should dare to maintain, in the presence of Understanding Persons, that the Watch which he carries in his Pocket, was framed in that manner, without any Wisdom or Design.

Sect. XIII. *Tranſition to a Demonſtration againſt Chance.*

But as little as we know touching the Manner of the Production of Humane Kind; yet in what we daily ſee thereof (tho' ſcarce obſerved by any) there is a very remarkable and ſtrong Proof of a Divine Providence, adapting all things to its wiſe Purpoſes, and a plain Demonſtration, that the World is by no means governed by Chance.

Before I propoſe it, I find my ſelf obliged to acquaint my Reader, that the Diſcovery thereof is owing to the Ingenuity of Dr. *Arbuthnot*, a famous Mathematician, Member of the Royal Society, and Phyſician in Ordinary to the late Queen of *England*, who has been ſo kind as to tranſmit it to me thro' the Hands of Mr. *Burnet*, the worthy Son of the late Biſhop of *Saliſbury*, ſo famous and ſo well known to the Learned World; the which Mr. *Burnet* is likewiſe himſelf a great Mathematician, and Fellow of the ſaid Society, and has allowed me the Honour to adorn this Treatiſe therewith.

SECT. XIV. *A Table of the Number of Males and Females Christen'd yearly in* London *in* 82 *Years.*

Ann.	Males.	Females.	Ann.	Males.	Females.
1629	5218	4683	1679	6278	5719
30	4858	4457	71	6449	6061
31	4422	4102	72	6443	6120
32	4994	4590	73	6073	5822
33	6158	4839	74	6113	5738
34	5035	4820	75	6058	5717
35	5016	4928	76	6552	5847
36	4917	4605	77	6423	6203
37	4703	4457	78	6568	6033
38	5359	4952	79	6247	6041
39	5366	4784	80	6548	6299
40	5518	5332	81	6822	6533
41	5470	5200	82	6909	6744
42	5460	4910	83	7577	7158
43	4793	4617	84	7575	7127
44	4107	3997	85	7484	7246
45	4047	3919	86	7575	7119
46	3768	3995	87	7737	7214
47	3796	3536	88	7487	7101
48	3363	3181	89	7604	7167
49	3079	2746	90	7909	7302
50	2890	2722	91	7662	7392
51	3231	2840	92	7602	7316
52	3220	2908	93	7676	7483
53	3196	2959	94	6985	6647
54	3441	3179	95	7263	6713
55	3655	3349	96	7632	7229
56	3668	3382	97	8062	7767
57	3396	3289	98	8426	7626
58	3157	3018	99	7911	7452
59	3209	2781	1700	7578	7061
60	3724	3247	1	8102	7514
61	4748	4107	2	8031	7656
62	5216	4803	3	7765	7683
63	5411	4881	4	6113	5738
64	6041	5681	5	8366	7779
65	5114	4858	6	7952	7417
66	4678	4319	7	8379	7687
67	5616	5322	8	8239	7623
68	6073	5560	9	7840	7380
69	6506	5829	10	7640	7288

In this Table it is remarkable:

I. That at *London*, in these 82 following Years, the Number of Males has exceeded that of Females every Year.

II. That the Difference thereof has always lain between two Terms, not far from one another. So that,

III. There were always more Males born than the half the Children amounted to in one Year. And,

IV. That the Number of the Males never exceeded that of the Females so far, that almost all the Children should be Males.

Sect. XV. *A Judgment upon the said Table.*

Now, forasmuch as by Sea and Land-Fights, by other dangerous Occasions, and especially by a more irregular way of Life among the *Men*, a much greater number of them do daily perish than of the *Women*, by such Distempers that are peculiar to them; can it be thought that it happens without a particular Direction of Providence, that there are constantly more *Men* born than *Women*?

And (which is wonderful) that there are but just so many more, that there still remains for every *Woman* a *Man* of her own Age, in her own Country, and of equal Condition to her. This is confirmed by a perpetual Experience, to the Satisfaction of every one that makes use of his Reason.

From whence Dr. *Arbuthnot* observes, that it seems to be plainly deduced, that *Poligamy*, or the marrying of more Wives than one, is as opposite to Nature, to the Government of the World, and the common Interest of Mankind, as it is contrary to the particular Laws of every Country; because, if one Man has several Wives, so many other Men must remain without them; besides, that it should seem that many Women cannot be so well impregnated by one, as each Woman by her own Husband.

Sect. XVI. *The first Mathematical Demonstration, that the World is not governed by Chance.*

But to come finally to the chiefest Proof that may be drawn from hence against an Accidental Cause; since Dr. *Arbuthnot*'s Business would not allow him to follow this Table in all its Particulars, and from thence to form a Calculation (which, according to the common manner, would have required the continual Labour of several Months, as is well known to those that are vers'd in the Computations of the Games of *Chance* or *Hazard*;) he therefore supposes, for Convenience sake,

I. That if an equal Number of Pieces of Money were thrown up into the Air, the Chance of their falling *Cross* or *Pile*, as it is commonly called, would be equal; so likewise among any equal number of so many Children, there would be just as many *Males* as *Females* born in the World, if those Births happen'd by meer Chance.

II. This Gentleman shews, that if a Person (whom we shall call A) should have laid the Wager D, that in tossing up some thousand Pieces of Money, there

there would have fallen as many Croſs as Pile, the ſaid A would have had a very ſmall Chance of winning his Wager D; and that the value of his Chance would have been much leſs than $\frac{1}{2}$ of D.

III. But becauſe the former Suppoſition, that the Number of *Males* and *Females* is yearly equal, does too much leſſen the Chance of A, that lays ſuch a Wager; Dr. *Arbuthnot* does again advance, that in order to make good ſuch Diminution, the Chance of A (which is otherwiſe ſhewn to be of much leſs Value than $\frac{1}{2}$ the Wager of D, every Year, or every Time) is now really ſo much greater, and its value is compleatly $\frac{1}{2}$ of D.

VI. This being now laid down, if a Perſon (whoſe Chance is $\frac{1}{2}$ of D) ſhould wager that ſuch a thing ſhould happen 82 times to one; or rather, that there ſhould be as many *Females* as *Males* born every Year for 82 Years together; as he had wager'd before, that there ſhould be ſo in one Year; they who underſtand the Computations of Hazard or Chance, know that his Chance will be as $\frac{1}{2}$ eighty-two times multiplied into itſelf, and afterwards with D; or that there is ſo great a Number (as is required when the double Number of 82 times multiplyed by itſelf, and the Unit ſubſtracted from it) againſt One; that the ſame ſhould not come to paſs by Chance after this manner 82 times together: Which therefore makes a Number of 25 Numerical Figures following each other, the firſt five whereof are 48357; as may be proved by the Logarithms with very little trouble. They that would know it more exactly, may compute it farther by the ſaid Logarithms; or elſe multiply the double Number 82 times by itſelf, and ſubſtract the Unit.

Now in caſe it is ſo many againſt One, that this ſhould not happen in *London* 82 Years together; let any one, experienc'd in Calculations, conſider how great a number there will be againſt One, that the ſame thing don't happen throughout the whole World, and ſo often in 82 Years following; and then let him judge, whether it can be believed that Chance has any place here: For that this has really happen'd many Ages together, and in all Places of the World, may be maintained with great Probability, becauſe, that in all Times, and in all Places, the *Men* are expoſed to more Dangers than the *Women*; and nevertheleſs there will be found in all Countries *Men* for *Women*, and *Women* for *Men*, of equal Age and Condition.

Sect. XVII. *The Difficulties and Objections that ſome may make againſt theſe Calculations, anſwer'd.*

Thus far Dr. *Arbuthnot*, whoſe brief Remarks upon what has happen'd, according to this Table, is ſo ſtrong a Proof of a wiſe Government of the World, that the ſame ought fully to ſatisfie every one who underſtands this Calculation. But ſince ſome Atheiſts, willing to evade the Force of this Argument, might ſtart the following Objection, That Dr. *Arbuthnot*, to avoid trouble, ſuppoſes the Chance of one who lays a Wager, that ſuch a thing ſhould happen in one Year to be as $\frac{1}{2}$ D, which does not agree juſt literally with the Table; let them know, that the ſole Miſtake that can be ſaid to be made therein, is only this; That this Gentleman allows too much to

thoſe that aſſert a Chance in theſe Matters, by ſuppoſing the Odds to be $\frac{1}{2}$ D; and that therefore the Number, that according to his Hypotheſis ſtands againſt One, is much ſmaller than would be produced upon theſe Grounds by a more accurate Computation, in caſe he could have allowed the neceſſary Time for making it. This is obvious to all that underſtand this Computation, ſince, allowing his Adverſary the half of the Chances, he will win if there be only more Pieces of Money falling Croſs or Pile, or more Males than Females born, without any Limitation, when the number of the Pieces, or of the Children, is unequal; and in an equal Number of Pieces, or of Children, the Adverſary would over and above have for himſelf the half of all thoſe Chances which an equal Number of Croſs and Pile, or an equal Number of Males and Females, ſhould give: Whereas, according to the Table (by reaſon of the Limitations, between which the Majority of Males is really found) a great many Chances, in which there are more Males than Females, would make them loſe; as alſo all the Chances which an equal Number of both would produce: Which does not want to be demonſtrated for ſuch as are only experienced in the beginning of theſe Calculations. I thought it my Duty to add this, in order to clear the ſaid Calculation, which indeed is ſtrong enough, but was however framed with a Deſign of not ſpending too much Time upon it, from all the Objections of ſuch as pretend to cavil at it.

And all that we have here ſaid, *viz.* that Dr. *Arbuthnot*, to avoid the Trouble and Time that ſo nice a Calculation would have required, has granted his Adverſaries much more than was neceſſary, may viſibly appear from the Calculation, which that moſt ingenious Mathematician, Mr. *s'Graveſande*, Profeſſor of Mathematicks at *Leyden*, has been pleas'd, after a particular manner, to make upon it; by which the uſual Method neceſſarily required in the Diſcuſſion of this Matter, and in which a vaſt deal of Pains and Time is taken up, is extreamly abridged.

SECT. XVIII. *A ſecond, and more accurate Mathematical Demonſtration, that the World is not govern'd by Chance.*

THIS Gentleman therefore reſolving not to confine himſelf to any particular Hypotheſis, and with a cloſer view to the Numbers of the Table itſelf, in order to diſcover that Number ſtanding againſt One, that what happen'd in *London* in the above-mention'd 82 Years, would not have happen'd if it had been the mere reſult of Fortuitous Cauſes, adds up all the Children born in thoſe 82 Years, in one Sum together, and finds that the 82d Part thereof amounts to 11429; which Number is therefore the Medium, or Middle Number, which, in caſe there were ſo many Born yearly, would again produce in 82 Years the ſame Number of Children as the Table contains in its Total.

Finding moreover in the Table, that in the Year 1703, the Difference between Males and Females, in proportion to the Number of Children, was the ſmalleſt; and that in the ſaid Year there were but 15448 born in all, of which 7765 were Males, and 7683 Females, he takes the middle Number to be 11429; and according to this Calculation, he ſuppoſes there to be 5745 Males, and 5684 Females. In

In like manner observing, that in the Year 1661 the Difference between Males and Females was greatest, if calculated again according to the aforesaid middle Number 11429; the Males of that Year will come out 6128, and the Females 5301.

The first Question then which is here to be answered, may be proposed after the following Manner:

A wagers with B, that if 11429 Pieces of Money be thrown up in the Air, there will not fall down of 'em fewer than 5745 Cross, nor more than 6128; or thus; that among 11429 Children, born every Year according to this *Medium*, there will not be fewer Males than 5745, nor more Females than 6128.

The Question then is, concerning the value of the Chance of A? Or rather, how many Chances there be against One, that what A has wager'd shall not come to pass, if all things depend on Fortune?

Sect. XIX. *The Calculation after the common Manner.*

To return an Answer to this Question, let it be supposed that C signifies Cross, and P Pile, or Males and Females, then they who understand the Modern Calculation of the Games of Hazard, know,

I. That the *Binome* C P, or M F, must be raised to the Power of which the *Exponent* is 11429, or the said Sum of 11429 must be multiply'd by itself.

II. That all the *Co-efficients*, or *Genitures* of the Terms, taken together, or the Power of the two Numbers, whereof 11429 is the *Exponent*, yield the Quantity of all the Chances that can happen concerning the said 11429 Pieces of Money. We will call the same $p + q$.

III. That all the *Co-efficients* as well of both the Terms, in which we find $k^{6128}\, m^{5301}$, and $k^{5745}\, m^{5684}$, as of all the Terms that are between these two, being added up together, make up the number of all the Chances which will cause A to win. We will call it p.

IV. That all the other possible Chances, except those which cause A to win, are to the Advantage of B, and these we will call q.

V. Wherefore if D be put in, that the value of the Chance of A, is $\frac{p}{p+q}$ D, when A has wager'd or laid that it shall happen once, in the Money thrown up, or with the Children in one Year.

VI. And therefore the Chance of the Wager laid by A, that it shall so happen, against that of B, who has laid the contrary, (supposing it all mere Hazard) is as p^{82} to $p \mp q^{82} - p^{82}$, or, to make use of the Unit, according as it is expres't in the former Question; as 1 to $\frac{p \mp q^{82}}{p^{82}} - 1$, that is, as the Unit, to a Number which is found by dividing the Quantity of all the possible Chances $p \mp q$ by p; or by the Quantity of all those that cause A to win, and substracting the Unit from this Quotient multiply'd 82 times by itself.

Sect. XX. *This Tedious Calculation contracted.*

All this, as we have said above, is well known to such as are vers'd in the Computations of the Chances of Games, but it is however very certain,

that as short and easy as the Solution of this Question appears to be in Words and Algebraical Letters, yet the nimblest Arithmetician, considering the Greatness of the Numbers that are to be found, would want some Months to dispatch it, if he would express it properly by Numbers, and would also be satisfied, that there were no Mistakes in his Calculation. Wherefore the aforemention'd Mr. *'sGravesande*, according to his vast Experience and Skill in Mathematics, has remarkably abridged this Matter, and cut off the much larger Part of the tedious Work, which the common Method naturally requires, shewing demonstratively, and with incomparably less Pains, that the *Ratio* of the Chance of A to that of B, found in the foregoing *Section*, as 1 to $\frac{p+q^{82}}{p^{82}} - 1$ (not only with the requisite Exactness, but even the causing several very small Fractions, which would otherwise have been neglected, to tend to the Advantage of A, and thereby not to be liable to any Contradiction) I say, that the said *Ratio* may be expressed by the *Ratio* of the Unit to a Number, which results or is found by the multiplying $\frac{2319680}{384950}$ eighty two times by each other, and substracting the Unit. So that with very little trouble and by the help of the *Logarithms*, we may see that there is a Chance of 44 Figures (of which the first five are 75598) against 1, that what happen'd in *London* in the said 82 Years, would not have happen'd, if it had been directed by Hazard only.

Mr. *'sGravesande*, who has computed the same by Logarithmical Tables, finds it to be, 75, 598, 215, 229, 552, 469, 135, 802, 469, 135, 802, 469, 469, 135, 802, 469, against 1.

Sect. XXI. *Convictions from the foregoing Calculations.*

Now let every Man, that can represent to himself the Greatness of this Number, judge whether it is a wise Direction, or Fortune and Hazard only, that takes place in this Matter; the rather, if he considers how much greater this Number or Sum would be, if the same thing happen not only at *London*, but throughout the whole World, which for the Reasons already alledg'd, is very probable.

This is certain, that since this Sum is greater than all the Grains of Sand, which some Millions of Globes, like that of the Earth, can contain, he that thinks it credible that what happen'd at *London* fell out by pure Chance, must likewise maintain, that he thinks it as probable, that a Person deprived of his Sight and Feeling, and who has no manner of Rule for the Direction of his Hand, and therefore must abandon himself entirely to Chance, should single out one particular Grain of Sand out of such an unconceivable Heap jumbled all together, the very first time he should put his Hand into it.

Sect. XXII. *Expression of the Number found in common Words.*

Before I quit this Subject, since there be among these Philosophers who ascribe all things to mere Chance, some also that are not used to extend their Speculations to Arithmetic, or Numbers, and to whom the common Expressions of *Billions*, *Trillions*, and the like, are unintelligible, and consequently make

make no Impression on them; it may not perhaps be unprofitable, in order to give them a more convincing Conception of the Number discover'd by Mr. *'sGravesande*, §. XIX. to express the Greatness thereof in such Words as every Body understands.

For which Purpose we know, that when this Number of 54 Figures is divided by the Unit with 39 Noughts, or Cyphers, following (§ XIX.) there will remain a Dividend of 75598, and a Fraction besides. From whence it follows, that if we multiply a Number of *an Hundred Thousand times a Hundred Thousand Millions* first with *a Hundred Thousand times a Hundred Millions*, we must take *Ten Millions* of this prodigious Number above *Seventy five Thousand, five Hundred, and Twenty eight times*, before we can come at the Number or Odds against One, that what happen'd at *London* in the aforesaid *Eighty two Years* would not have so happen'd, if the Birth of Males and Females were the Result of mere Chance only.

CONTEMPLATION XVII.

Of the Air.

Sect. I. *Transition to the Contemplation of the World.*

WE have hitherto been employ'd in Contemplating what we our selves are, and with how much Wisdom and Power, and (what lays us under higher Obligations) with how much Goodness our most Gracious Creator has thus wonderfully formed us, and daily and hourly preserv'd us. If now we proceed, and observe all that is round about us, we shall again discover a whole World full of innumerable Bodies, innumerable Motions, innumerable Phænomenas, or Appearances, innumerable Operations and Effects of an inexpressible Number of Things; so that the most laborious and diligent Enquirers, after their indefatigable Diligence, have made so little Progress, as to be forced to acknowledge, that all that they know of the Universe, even at this time, is but a small Part of what is still to be known. However, as little as this may seem to be, it is yet so considerable, that it must cause every Man that is not vainly puffed up with the Conceit of his own Wisdom, to sink down into the deepest Humility and Submission, when forced to confess a Glorious Creator, from the Contemplation of the most amazing Greatness of his Works; so that it is not possible (unless the Vengeance of God unjustly blasphem'd rests upon him) that there should be one single Soul so miserably blind and unhappy, as to think it credible, after a regular Inquiry, that so many and so wonderful things, that for so many Ages together, could continue without Change and Confusion in their first ap-

pointed Order and State, can be the effect of mere Chance and ignorant Cauſes. Beſides that, as unconceivably great and terrible as they may appear with reſpect to Men, they are nevertheleſs compell'd by an inviſible Power and Direction, not only to concur in preſerving us alive, but alſo to contribute, after ſuch different ways, to our Convenience, Refreſhment, and Pleaſure.

And that we may not be ſuppos'd to advance this, from an Admiration merely groundleſs, (for Admiration may be owing to Ignorance, as well as Knowledge) of the many Properties of Things, whoſe particular Diſcuſſion would not only exceed the Deſign of this Book, but even our Strength and Underſtanding, let us take a few into Conſideration, in which the Great Creator and Ruler of the World has vouchſafed to reveal his Ways in ſome meaſure to Mankind: And further, ſeriouſly reflect with our ſelves, whether they may not chearfully and undeniably ſerve to convince a Mind deſirous to know its Maker, that we have much more reaſon to acknowledge, in the Structure of the Univerſe, a Wiſe, Powerful, and Gracious Being, than the Skill of an Artificer from the moſt curious Machine that ever was produced by the Ingenuity and Workmanſhip of any Man whatever.

Sect. II. *Firſt of the Air.*

To avoid Confuſion, and obſerve ſome Order in the Contemplation of ſo many things, we ſhall begin with thoſe that are abſolutely uſeful and neceſſary to the Preſervation and Well-being of Man; therefore we ſhall treat of Air, which is the Principal of them all; and firſt, of ſome Properties thereof, and then of what Advantage and Service it is to Men, Beaſts, Plants, and other Things; all which we ſhall briefly ſhew in ſome few Caſes.

Sect. III. *The Gravity and Elaſticity of the Air.*

The Diligence, or rather the good Fortune, of the Philoſophers of the laſt Age, has brought to light, two remarkable Diſcoveries, and which were entirely a Secret to all the Ancients, touching the Conſtitution of the the Air; namely its *Gravity* or Weight, and its *Spring*, called in *Latin* by the Modern Naturaliſts, *Vis Elaſtica.*

Sect. IV. *An Experiment concerning the Gravity of the Air.*

For ſome thouſand Years the Air was eſteem'd to be a Body ſo light, that it would never deſcend like other Bodies, till the Invention of *Barometers* gave the firſt hint to Mankind, that the Air might likewiſe be a heavy Body.

And how greatly the Experiment of theſe Weather-Glaſſes has contributed to the chief Proofs of the Gravity of the Air, may be ſeen by the Suſpenſion of the Quickſilver in thoſe Tubes in many Caſes, which is to be aſcrib'd, firſt to its Elaſtic Faculty, and afterwards to its Gravity, which cauſes the ſaid Faculty to exert itſelf; as will appear by what follows.

Where-

Wherefore, in order to prove directly the Gravity and Weight of the Air, this Method seems to afford the strongest Proof or at least the clearest and simplest: Take a Glass full of Air, and weigh it in a nice and exact Pair of Scales; then drawing out the Air as far as possible with an Air-Pump, and weigh it again, you will find that it was sensibly heavier before the Air was exhausted than it is afterwards. The hollow Glass Balls which are commonly sold with the great kind of Air-Pumps, are very proper for such an Experiment, and bigger Glasses are yet more so.

I find in my Notes, that such a Ball, or Bubble, had lost with its Air, sixty two Grains of its Weight, which is more than sufficient to convince us of the Gravity of the Air. According as we make use of bigger or smaller Bubbles, this Difference will appear greater or less.

Sect. V, and VI. *The Air's Elastick Faculty, proved Experimentally.*

The second Property, for the Knowledge of which we are beholden to the Discoveries of later Years, is the *Elastick* Power or *Springiness* of the Air; whereby its Parts, like Steel Springs that are bent with Force, do continually endeavour to expand themselves; and so by their Separation from each other to take up a large Space, driving away and pressing on every Side, all that makes any Resistance to them.

To prove this, many Experiments have been made by the famous *Boyle*, and others. The common Method of shewing it, is by a little Bladder E, (*Tab.* XIII. *Fig.* 1.) which is about as big as a large Goose Egg, when full blown. Squeeze the Bladder so as to leave but a very small quantity of Air in it: Then having tied the Neck close, hang it up by its String to the little Hook D, of the Glass Receiver A B C, which being laid on the Plate of the Air-Pump B A, if you exhaust the Air from the Receiver at F, which pass'd on the outside of the Bladder, the Spring of the Air in the Bladder will exert itself so, that the Bladder will swell as if it was strongly blown up with a Pipe.

And for a further Proof of this Elastick Power of the Air, several other Experiments, hereafter quoted in the proper Places, may be serviceable.

Sect. VII. *The Pressure of the Air.*

Now that Operation or Effect which the Air has upon other Bodies, by this its Weight joined to the Expanding or Elastick Force of its Parts, is what the Moderns call the Pressure of the Air: The surprising Strength of which is incredible to many, and the Properties in its Uses no other than wonderful.

Sect. VIII. *The Mistakes of some Atheists.*

Now before we proceed any farther, let us answer these Men, who to defend their unhappy Notions, *viz. That there is not much Wisdom requisite in the Direction of many Things about them*, alledge, That most of those Things are either entirely at rest, or at least mov'd but very slowly, and think this a strong Argu-

Argument for their Assertions, because when things are suppos'd to be without Motion, there does not seem much Wisdom nor Power necessary to continue them in the State in which they are; because a slow and languid Motion is known not to want so much Force and Direction to prevent its doing Mischief, as that Motion which has more Velocity and Strength in it: And if this last be allow'd, the first carries a great deal of Probability with it, at least in the Minds of ignorant Persons: For several People sitting in a Chamber, for Instance, are not sensible of any Force upon them from Powers operating externally; the Glass of the Windows, that is known to be so brittle, remains in the same Condition; the Tapistry or Hangings of the Room immovable; not a Hair of their Heads stir; in short, every thing seems to them plainly enough to be in perfect Rest. Let 'em go abroad, and unless the Air be put into Motion by Winds or Storms, they meet with no violent Opposition, but every thing seems still and calm to them, excepting perhaps some uncommon Revolution or Changes, which, because they cannot easily trace the Causes, seem to be merely fortunous; from whence they conclude, that at such times they are safe and secure enough, and stand in need of no greater Power, than they themselves are able to furnish for their own Defence.

This Mistake does oftentimes render the unhappy Atheists very easie for a while, and makes them flatter themselves, that there is nothing about them which they need to fear. But in order to excite different Thoughts in them, and to make them apprehend Matters as they really are; let them go on and Contemplate with us those great and terrible Powers, which, even at the very time that they think themselves to be in the surest Calm and Stillness, move continually round about them, and they continually live in the midst of them; which Powers, if they were not most wonderfully restrained by an *Equilibrium* or Balance, (and so hinder'd from hurting us, and thereby only render'd insensible) would be able, as soon as ever that *Equilibrium* ceased to operate, in an instant of Time to crush us into Atoms.

Sect. IX. *A Description of the Barometers; and an Experiment of the Pressure, and of the Weight of the Air thereby.*

Now to the end that this may not appear to any one more marvellous than true; take a Glass Tube A O (*Tab.* XIII. *Fig.* 2.) of about three Foot in length, and of the Bigness of a Goose or Swan's Quill, closed at A and open at O; let it be filled with Quicksilver; then stopping the Orifice O with your Finger, turn it down into another Vessel of Quicksilver, as described here in the Glass B O D; then drawing your Finger away, the Quicksilver that is in the Tube will have an Opportunity of sinking down, some of it running to the other that is in the Glass. But it is well known to all that have taken any Pains to enquire into the modern Philosophy, that the said Quicksilver that is in the Tube will stop about F, at the Height F I of 28, 29, 30, or 31 Inches above the uppermost Superficies B D of the Quicksilver that is in the Glass Vessel. Now that this happens because the Air does press upon that Part of the Superficies B D, that is out of the

Tube, as much as the Quickſilver within does upon the Part C I, which is directly under the Tube, will appear from the following Reaſons.

I. Becauſe when the Preſſure of the Air upon the Quickſilver B D out of the Tube is greater or leſs, that within the Tube does either riſe or fall, as is obvious in all the *Barometers*, or Weather-Glaſſes, which are only made after this manner.

II. This may be likewiſe deduced from thence; that in caſe we pour Water, Lye, or any other heavy Liquor to the Height W K, upon the Quickſilver B D, and ſo augment the Preſſure with that additional Weight, the Quickſilver at F will be proportionably higher; and again lower, if we draw the Water off by a Pipe or Crane, and thereby leſſen the Preſſure upon B D.

III. The ſame is very plain, if we cover the whole with a long Glaſs Receiver, H G L, on the Air-Pump, and by exhauſting the Air in P, or in the ſaid Receiver; from thence into the empty Pump remove the Preſſure which this Air made upon the Quickſilver B D; for then we ſhall ſee that the other in the Tube between I and F, will deſcend to C I, or about as low as that which is in the Glaſs out of the Tube, and riſe again to the ſame Height F, when we let in the Air again to the Receiver, whereby the Preſſure upon the Superficies B D may be increaſed.

Hence then it is plain; that while the Quickſilver ſtands thus ſtill in the *Barometer*, and in the Glaſs Veſſel in the open Air, every ſimilar Part of the Horizontal Superficies of the Quickſilver Y X (which may be ſuppoſed to paſs through the Mercury under the Orifice of the Tube O M) ſuffers a like Preſſure; becauſe otherwiſe the Quickſilver would not remain at reſt, but the Parts of it that were more ſtrongly preſſed, would recede downwards; and the Parts that were leaſt preſſed, would be compelled to aſcend; which is ſufficiently known from the Principles of *Hydroſtaticks*: for which Reaſon then, if one ſuppoſes the Part N Q to be equal to O M, both of 'em will undergo an equal Preſſure; for the Parts of the Quickſilver R N Q S, and COMI, being of an equal Height, are likewiſe of equal Weight; and ſince they are at reſt, they muſt have the ſame perpendicular Preſſure; the Part R S, which is in the open Air, will be as much preſſed by the perpendicular Column of Air T R S V, as the Part C I, which is in the Tube, by the incumbent Column of Quickſilver Z F C I. And to conclude; each part of every thing that has Air impending over it, ſuffers as great a Preſſure as if there were a Column of Quickſilver of 28, 29, 30, or 31 Inches upon it, according to the Height in which it is found at that time in the Barometer.

Now, according to our Experiments as well as thoſe of others, Quickſilver is about fourteen times as heavy as the like quantity of Water, and ſo the Air preſſes as ſtrongly upon every thing over which it is impending, as if there were fourteen times twenty eight Inches, or reducing the ſame to Feet, as if there were 32 ½ Feet of Water (taking it at the very loweſt) lying upon it

SECT.

SECT. X. *A Barometer of Water and Lye, and some Experiments.*

NOW that we may not be here mistaken in the Deduction of Consequences, which often happens in Physical Enquiries; (forasmuch as when we think to have deduced by good Arguments a second Phænomenon from a once made Experiment, we do not always find the matter of Fact to agree with our Thoughts; since in the second Trial, other Causes may likewise intervene and co-operate, which we did not think of in the Deduction, as it happens to those that exercise themselves in such Enquiries more frequently than they could wish;) I therefore took a Tin Tube of 36 Foot in Length, but found, tho' it had been made with great Exactness, that it was not compleatly Wind-tight; wherefore there was another Tube of Glass of about the same length prepared, in order to make it a Barometer of Water: This was fasten'd to a piece of Wood, and then tied to the Sail of a Wind-mill, and so let down perpendicularly, its lower End being first stopp'd with a Cork and Bladder; after which, it was filled full of Water from above, stopping at every turn till the Air got above the Water; being full, it was after the same manner carefully stopp'd with a Cork and Bladder; then the lower Orifice of the Tube that stood in the Water being open'd, the Water in the Tube immediately descended, but stood still at the Height of about 33 Feet, as the Quick-silver does in a Barometer, till the upper Orifice being likewise unstopt, and the Pressure of the external Air thereby admitted, the whole Mass of Water that was in the Tube suddenly subsided into the Cistern. Thus this Experiment shews the Agreement between the Matter of Fact, and the Consequences that we have before deduced, touching the proportionable Gravity of Water and Quicksilver; namely, that Air presses upon all Bodies with the same Force as Water would, if it were incumbent on them about 33 Foot.

If any one should have a Mind to try the same Experiment, but had not the Opportunity of procuring from proper Glass-Blowers such a Tube of 36 Foot in Length, he may, as we do, make use of the broken Necks of Bolt Heads or little Chymical Phiols, which being thrust into one another, may be joined with the *Emplastrum de Minio*, or Red Lead, mix'd with Oil of Olives, and boil'd up to the Consistency of a Salve; and putting wet Bladder over it, bind it about with a small Packthread: This will make a Tube as perfectly Wind-tight for a while, and as good for the Purpose, as if it been one whole piece.

Another thing which must not be here past by, is, that the subsiding of the Water with an infinite Number of little Bladders, appeared ascending thro' the Water; which did not proceed from the external Air, but from that which was in the Water; the Cause of which was, that by the subsiding of the Water there was an empty Space left above in the Tube, and consequently the Pressure upon the Water was remov'd; whereupon the Air that was in the Water, expanding it self, ascended just after the manner as we see it happen in Water, under the Bell of the Air-Pump, when the Air that pressed upon it at first is exhausted.

They

They that desire to be entirely satisfied of what we here mention, may fill the Tube of the Barometer (*Tab.* XIII. *Fig.* 2.) A O M, with Water instead of Quicksilver, and place it in the Glass Vessel that is likewise filled with Water up to B D; then pumping the Air out of the Receiver H G L, they will see the Water subside from A to F, and lower, but in the mean while, numberless little Bubbles ascending in the Water, for the Reasons before mention'd; and that those Bubbles are really Air, and not Water it self, may appear, *First*, by letting the Air into the Bell again, because that the said Air remaining above at A F, will hinder the Water from being pressed by the Air P, and rising higher in the Tube than F. *Secondly*, Because if you exhaust the Air that is in the Receiver at P any farther, the Air at A F expanding it self, will press the Water a great way beneath C I, or B D, where descending only by its own Weight, it would have stopp'd by it self. *Thirdly*, For a farther Proof of the aforesaid Proposition, you may see by taking away the Receiver H G L, and holding a Coal of Fire near the Air at A F, that the Water being rarified by the heat of the Coal, will be pressed down to Z F; which assoon as the Air at A F becomes cold, will ascend again.

I find these Particulars among my Notes upon this Experiment, to prove that it is not possible to make a lasting Barometer of Water, which would otherwise have a great many Advantages over those of Quicksilver. If instead of Water one should take Lye (which tho' it had stood six Years in the open Air, had never admitted any Air into it, at least as far as could be discover'd by the help of an Air-Pump) it might perhaps furnish us a useful Barometer, and in my Opinion, even better than one of Water, out of which the Air has been driven by Boiling, because after a while the Air mingles it self again with the Water.

I hope this Account will not be unacceptable to such as do not understand the true Properties of the Barometer, tho' it be now very common; the rather, because what we have said above (namely, that the Force with which the Air presses upon all things is equal to that of a Column of Water of about 33 Foot in Height) is shewn in all its Circumstances; and so every one that represents the thing to himself, may consider the terrible Powers which, tho' he feels nothing of 'em, are continually exerting themselves upon, and round about him.

Sect. XI. *The dreadful Pressure of the Air upon a Man.*

Now to shew the incredible Greatness of that Force which the Air exercises upon our Bodies, let us for once suppose (it being too laborious and unnecessary also to describe the same with the utmost Exactness) that a Man of six Foot in Height, is one Foot in Breadth from Top to Bottom, the broader and narrower Parts being reckon'd together; so that the Superficies of his Body, both before and behind, may comprise 6 Foot each, the roundness of the Sides being counted in, if this Computation should seem too large.

Now, according to what has been said, every Foot in Breadth sustains as much Weight as if there were a Column of Water of 30 Foot at least upon it; we put 30 instead of 33 Feet here, because the Air has a different Weight at different Times, and the very smallest of it will be a sufficient Proof of our Hypothesis.

And every cubical Foot of Water weighs about 63 Pounds, as we have found it upon Trial; tho' others make it a little heavier, which may proceed from several Causes, such as the difference of Waters and Seasons, and of the Mixture of more or less Air therein; but this is not Material, for the smallest Weight is here the strongest Proof.

This then being suppos'd, altho' this Pressure upon our Body is mostly sidewise, and (accepting that upon the Head) is rather a lateral than perpendicular Pressure; yet it is well known to those who understand *Hydrostaticks*, that by reason of the Height of the Air, and the smallness of a Foot with respect thereto, there is little difference between the lateral and perpendicular Pressure; and he that is no Mathematician may likewise experience the same; because, whether he stands upright, or whether he lies all along upon the Ground (at which time the Air will press perpendicularly upon every part of his Body) he does not perceive the least Difference.) From whence it then follows, that upon every Superficies of one Foot of our Body, there always lies a Weight of 30 times 63, that is, 1890 Pounds; and accordingly, upon 6 Foot, which we have supposed to be the Breadth of the Body, 6 times 1890, that is, 11340 Pounds, with which Weight our Body is pressed only before, or behind; so that if you take the whole Force of the Pressure, which is equally sustain'd on both sides of the Body, the whole Weight will amount to 22680 Pounds. Now, to avoid any mistake, we will suppose it in round Numbers to be no more than 20,000 Pounds, which is certainly not too much.

Sect. XII. *Convictions from the foregoing Observations.*

Now could any Body have imagined, if this irrefragable Truth had not been demonstrated by the plainest Experiments, that when he thought he was free, and felt nothing, he should be loaded upon every part of his Body, before and behind, with no less a Weight than that of 20,000 Pounds; and that nothing could have saved him from being crushed to pieces by so terrible a Force, than that exact Balance of another Force against it; whereby the one operates just as much in favour of us, as the other would do to our Prejudice.

Now, that this most astonishing Force would be more than sufficient to crush our Body to pieces, can be doubted by no Body; forasmuch as if the Pressure of 10,000 Pounds Weight upon one side should cease to resist or balance the like Weight on the other, our Body would feel the same, just as if a Weight of 10,000 Pounds did press upon the forepart of it, not only slowly and gradually, which would yet be enough to deprive us of Life, but as much as if the like Weight of so many Thousand Pounds were suddenly cast against our Body: For the Elastick Power of the Air, if the Balance

thereof be taken away, exerts its Pressure with a more terrible Velocity than can be imagined. Now since every one of us is bound to acknowledge herein a Power preserving him every Minute from utter Destruction, and that the same Power operates according to the Rules of a wonderful Wisdom; can we do otherwise than ascribe all this to an infinitely Wise Director? And if it cannot be deduced from ignorant Causes, let the Atheist consider with himself what he has to expect for such blasphemous Negations of so wise and mighty a Being.

SECT. XIII, *and* XIV. *Experiments shewing the Pressure of the Air.*

Now as strange as all this may appear to any Body, yet all they who are used to Pumps, know that it is true: For if on the Top of a round Brass Vessel (*Tab.* XIII. *Fig.* 3.) which is open at C D, you fix a flat Glass A B, which is adapted to the upper Orifice thereof; and (to prevent the Entrance of the least external Air N, and Mixture with that of K in the little Vessel) thro' the Passage which is between the Glass A B and the Circumference of the Vessel, it being stopt with a mixture of Sheeps Suit and Wax; and so set down together upon the Brass Plate H I, of the Air-Pump and its Leather; then the Glass A B (like all others that are in the Air) will remain wholly unmoved between the equal Pressure of the opposite Air at N and K, as is sufficiently known.

Now that this only happens on account of the exact Balance of both those Columns of Air, by means of which the Air at K presses the Glass upwards with just as much Force as the same is prest downwards by that at N, may appear from hence; forasmuch as when the Force of the Air at K is never so little diminished, by pumping out some of it, one shall see that the Column E A B F, of the external Air N, pressing upon the other side of the Glass, will not only burst it, but will break it all to pieces, with a Noise like the Discharge of a Gun; which, to perform in the like manner, would require a very great Strength and Swiftness in the Blow of a Hammer.

The said Force of the Air appears likewise by exhausting as far as one can the Air out of a Globe of Glass A B, (*Tab.* XIII. *Fig.* 4.) and afterwards having turned the Cock E, by taking the same off, and placing it in a Vessel of Water L F G M, with its Orifice D downwards: Then turning the Cock E back again, whilst it is under Water, so that the said Water may enter into the Globe by the part D B; whereupon immediately as soon as the Cock E is open'd, the Air at H and K, gravitating or pressing upon the Water L M, which is on the outside of the Tube D B, exerts Force, causing the Water to spring thro' the Tube into the empty Globe with as much Violence and Swiftness as a Fountain, so that it will very much surprise those that have never seen the like.

Now the Cause thereof is, that by exhausting the Air out of the Globe A B, the Opposition or Resistance is likewise taken away; which otherwise, when the Globe is full of Air, does with equal Force withstand the Water to be driven up thro' the Tube D B, by the Pressure of the external Air at H and K, is plain from hence; because we know that upon admitting the Air

again into the Globe, and putting every thing in *Statu quo*, there will not be the leaſt Motion diſcover'd in the Water; which being preſſed upwards and downwards with equal Force in the Tube BD, between the two Powers of the Air within and without the Globe, reciprocally acting upon each other, does conſequently remain quiet, and, as far as it appears, without any ſenſible Diſturbance.

Sect. XV. *Convictions from the foregoing Obſervations.*

Now I ſubmit it to any Body, who from what we have here ſaid has attained to a true Idea and Conception of theſe dreadful Powers of the Air, whether inſtead of believing that all things in which he can diſcover no Motion round about him, do remain at Reſt; whether, I ſay, he is not now convinced that he is every moment of his Life encompaſs'd with ſuch a Force as acts upon him and every thing beſides; and of which, if the Wiſdom of the Great Director did not hinder it by an *Equilibrium*, from exerting all its Strength upon him, the half only would ſuffice to cruſh him and every thing elſe breathing, to pieces; and conſequently, whether he can imagine, that it is by mere Chance only, and without any Wiſdom, that while he walks in the midſt of it, he is preſerv'd from the fatal Effects thereof; the rather, if he does at all reflect upon the following wonderful manner of ſuch Preſervation. As *firſt*, that a very ſmall Quantity of the Air, and which is hardly worth naming, ſhould be capable of making a Reſiſtance, and of balancing an unſpeakably greater Quantity thereof, and hinder it from cruſhing moſt of the things that are under it. *Secondly*, that beſides ſuch a Reſiſtence, the aforeſaid ſmall Quantity of the Air does equally operate and gravitate with all the reſt of the Air extended even to the Clouds and higher. Now as the firſt hinders every thing from being deſtroy'd, the ſecond is no leſs uſeful to Men, tho' they are capable of uſing but a very little thereof.

Sect. XVI. *A little Air reſiſts a greater Quantity.*

One may ſee an Inſtance of the firſt in *Tab.* XIII. *Fig.* 3. where a Glaſs AB, impervious to the Air, is placed upon a little Veſſel A B C D; which ſtanding upon the Braſs Plate and its moiſten'd Leather H I, is thereby cloſed at Bottom, as it may be after another manner, if People will, ſo that the little Air at K, remaining incloſed therein, makes ſo equal and ſo compleat a Reſiſtance againſt the Air E A B F (which otherwiſe, as we have ſhewn above, breaks the Glaſs, and being extended from the Top of the Clouds down to the Earth, does a thouſand times ſurpaſs the Air at K, both in Quantity and Gravity) that the Glaſs A B, tho' never ſo thin and brittle, is not in the leaſt hurt thereby.

Sect. XVII. *A little Air gravitates as ſtrongly as a great deal.*

The *Second*, by which we ſee that a ſmall quantity of Air (beſides the Reſiſtance abovemention'd) does likewiſe gravitate and preſs equally with the whole external Air, may be firſt proved by *Tab.* XIII. *Fig.* 2. where the Quickſilver in the Barometer A I, with its little Glaſs B X, ſtanding in the

open Air, is thereby raiſed and ſuſpended to the Heighth F I. Now if you cover the whole with the Glaſs Receiver H G L, ſo that no Air beſides that which is in the Receiver can act upon the Quickſilver at B D; yet you will ſee that that which is in the Tube will preſerve the ſaid Height of F I. So that it is here proved unanſwerably, that the Air in the Receiver, how little ſoever it be, gravitates as ſtrongly, yea even more upon the Quickſilver at B D, than the whole external Air had done before.

But in *Tab.* XIII. *Fig.* 5. you may have an ocular Demonſtration of it, if you place a long Tube F O (like that of a Barometer, but open at both ends) in a little Glaſs Veſſel G K P Q, thruſting it thro' the Covering of the ſaid Glaſs Veſſel G K at I, and cloſing it round about; into this Veſſel you muſt pour thro' the little Hole at N, (which was ſtopp'd before with a Screw) ſome Quickſilver, till it riſe up to B D, a good deal higher than the End of the Tube O, whilſt the reſt of the Veſſel B D G K, has nothing but Air in it. Then ſtopping again the little Hole at N with the Screw, ſet the whole Apparatus under the Receiver H S L, and exhauſting the Air V V, you will ſee that the little included Air at G B D K, will loſe its Reſiſtance, and preſſing upon B D, by its rarifying and expanſive Faculty, will force the Quickſilver in the Tube to aſcend to the Heighth of F; which was about the ſame with that at which the Quickſilver remained ſtanding in a Barometer, when ſuſpended by the Preſſure of the whole Air.

SECT. XVIII. *The Difference between the Gravity and Elaſticity of the Air.*

NOW the firſt (that is to ſay, the Reſiſtance which a ſmall Quantity of the Air makes againſt a greater) is common to all other Liquids, according to the wonderful Laws of *Hydroſtaticks*, to which the weight of all Fluid Matters ſubmits itſelf in its Operations. Accordingly, we ſee that all Liquors preſs'd upon, do either preſs reciprocally, if they be elaſtical, or otherwiſe reſiſt like ſolid Bodies; as may be experienced in a cloſed Syringe or Air-Pump, in which there is either Water or Air; this laſt Effect however, ought to be rather aſcribed, as we think, to the Air's Elaſtick Faculty, than the Weight thereof, which appears from hence, that the Weight of the included Air G B D K, does hardly bear any Proportion to that of the Quickſilver in the Tube F I; and again, becauſe if we ſhould fill the Space G B D K, where the Air is, with a heavier Matter, or with Quickſilver itſelf, the Quickſilver in the Tube (tho' the Air were exhauſted out of the Bell) would not riſe higher than I.

SECT. XIX. *How the Elaſtick Power of the Air works by the Gravity thereof.*

NOW in order to underſtand in ſome manner, how the Weight of the Air and the Spring thereof, do produce theſe their Operations with one another, we muſt repreſent to ourſelves, that in *Tab.* XIII. *Fig.* 6. there is a Column of Air, A, H, conſiſting from Top to Bottom of a great number of Air-Particles, ſuch as A, B, C, D, E, F, G, P, *&c.* each of which have a certain Weight, whereby they gravitate upon thoſe that are under them.

We

We must likewise suppose, that in each of them (of what Figure soever they be) there is an inherent Elastical Power, by which, like the Steel Springs of Watches, *&c.* being bent together, they endeavour to expand themselves again with the same Force wherewith they were bent.

From hence it follows, that the lowermost Parts of the Air, G and P, *&c.* bearing the Weight of all those that are above 'em, must be more bent than those that are higher and bear a lesser Burden, as A B C; for which reason the undermost, P G, endeavouring more forcibly to restore themselves, will press the Body I K, that supports them, with more violence, as those that stand above the Body N O, do the same.

And so far the Point H bears no more than the Weight of all the Air-Particles A, B, C, D, E, F, G, P, *&c.* which stands upon one another, without any remarkable Alteration of the Elastick Power.

But if we proceed further, and place another solid Body between these Air-Particles, thereby cutting off those that are at P and G, from the aforesaid Column, and likewise encompass the place L I K M by solid Bodies, in such manner, that the Air-Particles, P and G, are entirely separated from the others. If now (as in Water which has little or no Elasticity) the Parts P and G did press by their Weight only upon the Body I K at H, the said Body I K, would be so much less pressed than before, that the Body L M was placed above G; forasmuch as I K does now only bear the Weight of P and G; whereas it had born before the Weight of all the Parts of the Air of which the whole Column A P consisted.

But supposing on the contrary, that the Parts A, B, C, D, E, F, G, P, had all, like the Air, an Elastick Faculty, and should again endeavour to expand themselves in Proportion to the Pressure of those above them, the Body I K will then be pressed as much by these two Parts P and G, as it was before by the whole Column of Air from A to P; for since the Parts P and G, that were cut off, are continued in the same Inflection, by the Resistance of the solid Body L M, which they had acquired by the weight of the incumbent Parts A, B, C, D, E, F; their Expansive Faculty, and consequently the Gravitation or Pressure which they make upon the Body I K at H, will remain equally great.

And thus we see, that the Weight of the Air-Particles, bearing upon one another from A to P, do press the lowermost P G; and bending the same, do encrease their Elastick Force: so that how little soever they might have been, whilst by the Resistance of a solid Body I L M K, they were hinder'd from expanding themselves farther, these few Parts P G, that are cut off and excluded from the rest, do press the Body I K, upon which they act, as much as if the whole Column of Air A P remained over them.

Now, that this last obtains in the separated Parts of the Air, has been lately shewn in §. XVII. from the Effects of the included Air in the Place G B D K.

SECT.

SECT. XX. *The Air that bears most Weight, is most compressed.*

WHAT we have just now said, namely, that the undermost Parts of the Air, P and G, being pressed by a greater Weight of those that are above them, will be more compressed than those of D and E, which have the shorter Column of Air, A C, over them, and consequently a lesser Weight, may be proved by the following easie Experiment among others: Take the Tube of a Barometer (*Tab.* XIV. *Fig.* 1.) let it be open at I, and shut at F; fill it with Quicksilver so far as to leave a little Air at the Top of it; then stop the Orifice I with the Finger H, and turn it suddenly upside down, so that the Finger which was before at the Top, may now be at the Bottom. This being done, you will see that the Air that remained in the Tube, and which, by the inverting thereof, does now bear the Pressure of the whole Column of Quicksilver, will be immediately contracted into a much narrower Space than it was at I; and that as it ascends thro' the Quicksilver from I to F, it will continually possess larger Spaces, because the incumbent Quicksilver does continually lose of its Height above it; and therefore the higher these Air-Bubbles come, the less Weight they feel; and this is the reason why they appear to us larger at A than at I, at B than at A, at C than at B, and so on, till they have got up as high as F, where being no longer pressed, they are expanded to the utmost Bigness.

We may likewise see the same Appearances, but with less difference of Size, if we fill the Tube with Water instead of Quicksilver: From whence it may be then concluded, that the Air which bears the greatest Weight, is also the most compressed.

SECT. XXI. *Air that is most Compressed, is most Elastical.*

NOW that the Air that is most compressed, does make the strongest Efforts to dilate or expand itself again, and accordingly presses more powerfully upon all the Bodies about it (besides, that the same appears from the Wind-Guns, and the little Fountains of *Hero Alexandrinus*) may be prov'd by a very easie Experiment, (*Tab.* XIV. *Fig.* 2.)

Take a Syringe, S D, (those that are used in Anatomical Operations are, by reason of the narrowness of the injecting Tubes, very fit for this Purpose) and drawing out the Piston, S C, half way as far as C, so that the Part A B remains full of Air; put the End or Nose of it, D, in Water, which will enter into it, by drawing back the Piston F G; then screwing upon it a little Tube D E, which has a small Orifice at E, if you lay the Syringe horizontally, so that the Water A may cover the Hole D, and the Air B remain over it, you will not be able to discover the least Motion therein; but if you suddenly, and at once, protrude the Piston from F G to C, so as to make the Water spout out at E, and the Air at B is the more compressed thereby; tho' you should immediately stop the Piston again, you will yet find, that the Air at B being more compressed, does likewise expand itself with greater Force, and presses upon the Water A; so that the Stream of Water E K, does thereby continue for a long time to run out at E, even tho' the Piston

Piston do lie still at C, and presses no farther; from whence what has been said above is proved.

Sect. XXII. *Convictions from the foregoing Observations.*

Now, if any would contemplate the aforemention'd Laws, and how the formidable Power of the Air is so wonderfully balanced by so small a part of the same; Can he still imagine, that all this is owing to Chance, without any Design or Wisdom of the Maker?

Without such a Law, and in case that the little Air which is in a Chamber could not sufficiently balance the vast Ocean of the external Air, how could it otherwise be, but that all our Glass Windows, like the Glass Vessel mention'd in §. XIII. should be immediately broken into small Pieces? Forasmuch, as according to the preceding Calculation § XI. upon every square Foot thereof there is a continual Pressure of above 1800 Pounds Weight. Without this Law, how could an Army Tent, a Peasant's House, or a Shepherds Cottage, yea even the most stately Edifices, remain standing? Since, if they be taken in their Largeness and Circumference, as an Apartment, which being but ten Foot in Length, and of the same Breadth and Heighth like a Dye, the four standing Sides, and the Ceiling, being each 100 Foot broad, and each pressed upon with 189,000 Pounds Weight, and consequently the whole Apartment would be pressed with five times as much Weight upon all its Sides, on which the Air is incumbent, that is to say, with a Weight of 945,000 Pounds. Whereas in the space of 1000 Foot, which the whole Compass thereof contains, the whole Body of Air that resists such an external Pressure, would not gravitate more than 63 Pounds; supposing, with many Enquirers, that a Cubic Foot of Water weighs 63 Pounds, and is a thousand times heavier than a like Foot of Air. Without this Law, how is it conceivable that we, who are continually pressed with a Weight of above 20000 Pounds round about us, should not have been long since crushed to Pieces, since the third Part thereof is able to do it? And in case our Breast, by the roundness of its Ribs and Cartilages, might make some Resistance, how comes it, that our Belly and Loyns are not pressed flat and close together by such a Force, were it not that they did contain some little Quantity of elastick Air, which, tho' so very small, is yet able to balance so terrible a Pressure? 'Tis by such included Air, that we see those Creatures that are put into a Glass Vessel, from which the Air is exhausted by the Pump, swell and grow bigger as soon as the said Air within them expands itself, for want of an external Resistance and Balance. This Experiment I find in my Notes to have been made upon a *Mouse*, a *Kitten*, and other such little Creatures.

Now can any one imagine, that forasmuch as without this wonderful Balance (by which a small parcel of Air is able to make head against a mighty Column extended from the Surface of the Earth up to the Clouds and higher) no House would be habitable, no Creature could remain alive, but every thing in the World would be broken and crushed to Pieces; I say, can any one imagine, that it is by Chance, and without any Design of the Creator,

that

that there is ſuch an amazing Balance provided againſt theſe great Powers, and that the Air and other Fluids are bound by certain Laws of Gravitation, which are obſerved to be ſo different from thoſe in ſolid Bodies? And whereas the laſt do only gravitate in proportion to their Weight, that in the Air, and other fluid Bodies, as has been ſhewn before, a little Portion of 63 Pounds in Weight, can hinder a perpendicular Preſſure of 180,000 Pounds, and a lateral Preſſure of about 900,000 Pounds from exerting its Force.

Miſerable Philoſophers! who finding themſelves every Minute of their Lives preſerved after ſo wonderful a Manner againſt ſuch dreadful Powers, from ſudden Death and other frightful Effects; yet, that they may not be forced to acknowledge with Gratitude, the Wiſdom, Power and Goodneſs of their Glorious Creator, will rather aſcribe all to mere Chance, operating without Laws or Reaſon, or elſe to Cauſes wholly ignorant of what they themſelves are doing! In caſe there were a Room of ten Foot in Length, and as much in Breadth, the Ceiling of which were made of Lead or heavy Stones, weighing 180,000 Pounds, which being looſe on all ſides, was only ſupported by a ſimple Balance, and thereby hinder'd from falling down upon the Floor, and cruſhing every thing to pieces that ſtood in its way; and in caſe one ſhould then put into the Hands of one of theſe Philoſophers, a Weight of 63 Pounds, and with that only, and without any Mechanical Inſtruments (at leaſt any that were made of a ſolid Matter) bid him balance that mighty Weight; could he expect any thing elſe, upon entring into a Chamber in ſuch a Poſition, but the miſerable Death of being cruſhed to pieces? And then if another Perſon, by inventing ſuch a Method, could prevent the Fall of this threatening and dreadful Weight with a Counterpoiſe of 63 Pounds only, without any Mathematical Inſtruments; would he not, if he had the leaſt ſpark of Generoſity in him, own the Wiſdom of the Inventer, (tho' he could not diſcover the Manner how) and extol it far above his own? And if he did not know the Manner, but was at the ſame time ſenſible that his own Power was much too weak to preſerve himſelf by putting the ſame in Execution, would he not think himſelf bound to confeſs with Gratitude, the Power and Goodneſs of this his Preſerver? And can he then live eaſie in theſe Circumſtances, and without making any Reflections upon them? Can he, knowing the terrible Greatneſs of theſe Powers (with which he is ſurrounded, and which if the Balance ſhould ceaſe to perform its due Functions, would threaten him with the ſame Dangers, and even with as unavoidable Deſtruction, as if he were to have expected the Fall of ſuch a heavy Ceiling) ſtill proceed, after being ſo wonderfully ſaved, blaſphemouſly to diſown the Preſervation? And the more, ſince if he underſtands the Uſe of the Barometer, the ſame would teach him, that theſe Gravitating Powers, as well as their Balances, are daily encreaſed and diminiſhed by Cauſes, which if he does know, yet neither he, nor any Man living, can prevent; ſo that it is impoſſible for him here to ſcreen himſelf behind Laws of Nature fixed and immutable, and always obſerving the ſame Courſe.

And to ſay no more, when he muſt confeſs, if he reflects upon what follows, that this Gravity and Elaſticity of the Air is ſo entirely neceſſary to the Support and Convenience of Men, of Beaſts, of Fiſhes, of Plants, that without the ſame, whatever lives upon this Globe would immediately periſh: And this Preſſure of the Air, among all thoſe Advantages which it imparts to all things, does likewiſe carry along with it this great Diſadvantage, that it is capable of bringing the whole Earth, and every thing upon it, to the extreameſt Confuſion, by cruſhing to pieces, and as it were annihilating, all that it ſurrounds, with its reſiſtleſs Power. Can he think that it is by Accident, and without Wiſdom, that there is a Means found out, by which every one is permitted to enjoy the Benefits of the Air, and yet is ſo well ſecured againſt the pernicious Effects thereof, that this great Preſſure, and this terrible Weight, is in a manner inſenſible and unobſervable even to the moſt tender Perſons?

Once again, if all theſe Experiments about the Gravity and Elaſticity of the Air, about its dreadful Force and wonderful Balance, by which the ſaid Force is hinder'd from deſtroying every thing, be not ſufficient to convince an unhappy Sceptick that there is a GOD, who in his Wiſdom has brought all this to paſs; let him go a little farther with us, and anſwer ſincerely, whether ſeriouſly reflecting upon all theſe things, he ſpeaks with a Conviction of Conſcience, when he aſſerts, that it ſeems to him to have come to paſs by Chance, and without any wiſe Direction, that ſuch a great Sea of Air has fixed itſelf round about the whole Globe of the Earth; which, if one may judge according to the moſt probable Opinions, is extended to ſome Miles in Heighth; and without which, every thing that breaths, would give up the Ghoſt. And who is there that cannot ſay experimentally, how much all humane and other Creatures are depending upon it? Which, tho' they are able to want both Sleep and Food for ſome Days, yet if they be depriv'd of this Air but ſome Minutes, they will infallibly periſh. And how neceſſary the Air is to them, will appear particularly from hence; That during the whole ſpace of their Lives, they are continually employed in breathing it In and Out; ſo that both theſe Functions even at the time of Sleep (which does otherwiſe free them from all their Labours) muſt be inceſſantly diſcharged, and without any reſt at at all, if they deſire to live.

Can even the boldeſt *Epicurean* imagine that ſo neceſſary a Subſtance has by mere Chance ſurrounded this Globe of the Earth, upon which all Men and Beaſts are placed by GOD, who would have beſtow'd all his Art, Wiſdom, Power and Goodneſs in vain, nor would thoſe noble Creatures have been able to have liv'd one Hour after their firſt Production without it. Nay, tho' they had ſprung up out of the Earth like Muſhrooms, according to the undemonſtrable, or rather ridiculous, Notion of *Epicurus* himſelf; yet he, and all his Followers muſt agree, that without Air they would have return'd to it again, and the World would have been without any one Man that could have lived or breathed but one Day.

Has there not then the Hand of a Wiſe Creator been viſibly employ'd herein, who has made this Air for the Preſervation of Men and Beaſts? To what

what purpose is their Body provided with such Instruments, which serve alone to this, and to no other end, than to enable them to enjoy the use of Air? And, not to repeat all that has been said before concerning Respiration, why have they *Lungs*, unless it be for the Reception of Air? Why do they lye in that place, and in such a Disposition, that the whole Mass of Blood may pass so often thro' them, but that it might partake of the Operation of the Air? Why are the *Diaphragm*, *Ribs* and *Cartilages* of the Breast so framed, that their principal, if not only Function, consists therein, to draw in and drive out this Air from the Lungs? To what End, that we may say no more, is this most ingenious Structure, which that it may not be easily hinder'd in so necessary a Work, does employ about a hundred Muscles in that whole affair of Respiration? Why are most of the Instruments which are useful herein, formed already in a Child before it is born, and at a time when there is not the least occasion for them, were it not that at the very instant when the little Creature comes into the Air, it should be able to use them for the support of its Life? And if these Philosophers can with a safe Conscience maintain that *Air*, and the Instruments of our Respiration have each of them acquired their Existence without any Design or Wisdom, why don't they say the same when they see a curious Strong Box open'd and shut with a fine Key adapted to it? Certainly if they would be counted wise Men, they would not dare to affirm it before any rational Creature.

SECT. XXIII. and XXIV. *The Elastick Power of the Air is the Cause of Suction; confirmed by an Analogous Experiment.*

IF the Air be produc'd by Chance; if it be by Chance also, that it is endowed with an Expansive and Elastick Power; it is then by the same Chance that any Child could ever suck a drop of Milk out of its Mother's Breast: For in case the Air, by the aforesaid Power, did not press upon all the Parts of the Breast, and cause the Milk to spring out of it at the time when the Child does, as it were with a natural Air-Pump, make a Vacuum in its Mouth before the Orifice of the Nipple, the least drop of Milk would not come out of it; by which means Young Children, and all other Sucking Creatures, would be bereaved of their best and most agreeable Sustenance. Now, can any one imagine, that in the Structure of the Breasts of Females, and that of the Tongue, Lips and Cheeks of Children, there should be found such an Aptitude and Faculty of making use of the Elastick Power of the Air, in a Business of such vast Importance as is the Sucking of New Born Children, whilst there is no other so appositе and so convenient a Method for that purpose; and that this Power of the Air, and the adapting thereof to those Instruments employed by Children in Sucking, should be only Accidental, and produced by an Ignorant Cause, without any respect to such a Design?

If a Man should look back to *Tab.* XIII. *Fig.* 4. and peruse again what we have said in §. XIV. when he sees the Water B C, spouting up into the Globe A B, exhausted of Air by the Pressure of the external Air H K, upon the Water L M, he may observe an Operation analogous and uniform

to that of a Child's Sucking; especially if he will suppose the Part A B to be the Child's Mouth, and the Vacuity form'd therein, and the Superficies of the Water L M, to be the Breast of the Mother. And that he may be yet more fully convinced of the exact Agreement between that and Sucking, let him stop the Orifice D of the exhausted Globe with his Thumb, and he will feel something, which if he did not know how it happen'd, he would not scruple to call Suction.

SECT. XXV. *Convictions from the foregoing Observations.*

To shew then, before we quit this Subject, the Unreasonableness of the Atheist from the Pressure which the Air alone produces in Childrens Sucking; if he dares not maintain, that both the Pumps in a Fire-quenching-Engine do, by pressing the Water, raise a mighty Stream thro' the long Leather Pipe thereof, without being adapted to such a Purpose by the Contrivance of the Artificer; Can he with any more specious pretence affirm, that the Air, which by pressing upon the Breast, forces the Milk to flow out of it, has acquired such a Property by mere Chance, to be applied to so much greater Uses, as the administring Food to a new born Child; and that not once (which perhaps one might affirm to be accidental) but in all the Parts of the whole Earth, where Children, and so many thousand other Creatures are brought forth? Can he not here discover a wise Design of the Great Director of all things? Why then does he not as boldly and peremptorily deny the Skill and Ingenuity of the Artificer in the Formation of an Engine or Fountain to raise Water, in the Pressure whereof there is neither so much Wisdom nor Usefulness to be discover'd, as is shown by the Air in the Circumstances abovemention'd.

Once again, if this Elasticity and Pressure of the Air is to be ascribed to Chance only, they that maintain such an Hypothesis for Truth, ought to live in a continual Fear, that the same Chance may likewise alter the Air, and deprive it of these Powers, whereby they themselves, and every living Creature besides, will be suddenly suffocated for want of Breath: For if all this comes to pass by Chance, and by the same Chance only is so continued to this very Hour, there is no reason to think, but that it may be immediately alter'd by a like Chance; since it is of the very Essence of Chance, to have nothing of Certain in it.

SECT. XXVI. *Experiments to shew that Living Creatures will Perish in a Place from which the Air is exhausted.*

Now that such an Apprehension would be very reasonable, appears; *First*, because we are taught by the Barometers, that (as has been shewn once before) this Elastick Force, whether it be from it self, or whether it proceed from a Change in the Weight of the Air, may be often visibly diminished, and upon that account the Quicksilver will subside. And, *Secondly*, because a great Diminution of this Elastick Power of the Air is in a manner fatal to all Creatures; certainly to most of those upon which it has hitherto been tryed: For Dogs and Cats, Rats and Mice, being placed under the Receiver

of

of an Air-Pump, become immediately ſick and out of order, as ſoon as the Elaſtick Power of the Air round about them is never ſo little diminiſhed, and as it is taken away more and more, they dye in a ſmall ſpace of Time. But if you take them out before they expire, and place them in another Air, the Elaſticity of which is greater, they will ſometimes recover, eſpecially if the Force of the Air be not too much diminiſhed before. Birds are uſually not able to withſtand this Alteration in the Air ſo long, but generally fall into Convulſions, which are preſently attended with Death. Flyes and Spiders (according to my Obſervations) after three or four Strokes of the Pump, ſeem to be wholly deprived of Motion, but when brought into the external and more gravitating Air, they begin to ſhew ſome tokens of Life again.

From theſe Appearances, and many more that you will meet with among the Modern Naturaliſts, it undeniably follows, that unleſs the Air were, thro' the Goodneſs of our Creator, preſerved in its preſent State and Condition, whereby every thing breathing is ſaved from immediate Death; and in caſe that it were nothing but mere Chance, by which the Air, without being ſubjected to any higher Laws, is render'd one while Stronger, and another while Weaker in its Expanſive and Elaſtick Powers, every Body would be in a continual Dread, that he himſelf, and all living Creatures round about him, would inevitably and immediately Periſh; the rather, becauſe ſeveral things, ſuch as Steel and others, in which there is an Elaſtick Force diſcoverable, are often found to be entirely diveſted of it, by remaining bent a long while; and ſo it would happen to the Air too, which, after ſuch an Expanſion, will not be able to reſtore it ſelf to its former Elaſticity and Spring.

Sect. XXVII. *Atheiſts deny their own Principles.*

This being proved by ſo many Experiments, and yet we being unable to diſcover ſuch a juſt Dread among the Atheiſts, it muſt undeniably follow, either that thro' their Blindneſs they are hinder'd from obſerving the Conſequences of their own Opinions, and therefore do treat this great Affair, which is of the utmoſt Importance to them, with ſo little Judgment and Underſtanding: Or, how boldly ſoever ſome of theſe miſerable Philoſophers may aſſert the contrary in Words, yet that they are convinced in their own Conſciences of the Falſeneſs of their Sentiments, and conſequently are perſuaded that it is by another Power, and not by ignorant Cauſes, they are preſerved, even without and againſt their own Will; and thus they deny their own Principles.

Sect. XXVIII. *To Die in an Unelaſtical Air, is no neceſſary Conſequence of Nature.*

That it is no fixed Law of Nature, that every thing that lives in an Expanſive and Elaſtical Air muſt immediately die when the Spring thereof is either weaken'd or totally deſtroyed, and therefore that theſe miſerable Cavillers do torment themſelves in vain, to deduce this Appearance from the unknown Laws of *Matter* and *Motion*, or from a Neceſſity determining every

every thing, may appear from hence; that the contrary is true in the case of a *Frog*, as many other have observed, of which I find among my Notes the following Experiment; That a *Frog* being put under a little Receiver of an Air-Pump, and the Air being exhausted from thence, not only the Belly thereof, in which one might expect there was Air, but likewise all the other Parts, as, Head, Legs, Muscles, *&c.* were swelled to a great Thickness; which, upon the admission of the external Air, did all subside again, and the Creature return'd to its first Size: But that which is most for our purpose is, that the *Frog* remained a quarter of an Hour in the Receiver entirely exhausted of Air, without appearing to be the least affected with it, and when it was let out, immediately sprung away, as if nothing had ailed it.

SECT. XXIX. *To Die therefore in an Air divested of its Elasticity, is the Result only of the Will of GOD.*

CAN it therefore be denied, that since all Creatures are not equally affected with the Elasticity and Gravity of the Air, what had been said before must not be admitted to be a general Law of Nature, which taking place between the Air and all Creatures, produces such Effects without Understanding? And must not that Man be allowed to argue much more rationally, that does acknowledge herein the Hand and Work of a wise Artificer, who, that we may not ascribe that which happens to most of the living Creatures, with respect to the Air, to necessary and unavoidable Consequences of ignorant corporeal Motions, has been pleased by such an Exception as this, and perhaps by many others, to shew that all must be resolved into his good Liking and Wisdom; and that He has thought fit that the Air, amongst its other Properties, should always preserve a certain degree of Force in its Expansion; without which the whole Globe of the Earth would be in a manner deprived of all Living Creatures? And likewise, that when he thought fit to order it otherwise, he could preserve some of 'em alive without Air.

SECT. XXX. *The Elastick Faculty of the Air is not alone sufficient for the Preservation of Life.*

FOR the Proof of this last Proposition, it may likewise be particularly serviceable to shew, that this Elastick Faculty of the Air is indeed necessary to Life, but that it is not sufficient alone. Thus we find in Times of Pestilence, that the Air is sufficiently Elastick, but nevertheless Contagious and Fatal. And the great Naturalist, *de Stair*, relates, that not only many other Creatures, but likewise a *Frog*, that can live in Air, in Water, and without Air, yet died in a little space of time with an Air or Steam that proceeded from Dough. And Experience does abundantly teach us, that a Living Creature shut up in the same Air, without any Circulation or Change therein, cannot long subsist so, altho' the Elasticity or Spring of the Air were not so much weaken'd, as that we should ascribe the Cause thereto; forasmuch as it appears by the Barometers, that the Air by which we are surrounded, can undergo great Alterations in its Elastick Faculty, without any

Prejudice to breathing Creatures. But if this Property of the Air, which, besides its Gravity and Elasticity, is necessary for the support of Creatures, we have already said something in our Discourse upon *Respiration.*

SECT. XXXI. *The Elastick Power of the Air does likewise cause Fish to live and subsist under Water.*

BUT before we take our leave of Living Creatures, can any one observe without Astonishment, that even the Fish in the Water do receive their Life and Well-being from the Pressure and Elasticity of the Air? Which being removed or taken away, scarce any of 'em can contain themselves under the Water, but, in spight of all the Resistance, must emerge and rise up to the top of it.

They that would see the Experiment of it, may put some Water and a Gudgeon, or any other little Fish, into the Recipient of the Air-Pump; and removing the Pressure of the Air, will find that a Fish immediately rises up to the Top, but upon letting in the Air, it will sink down again. The Reason thereof, and how the Bladders within their Body being dilated by the diminution of the Air's Pressure, and becoming larger, do render the Fish so much lighter than Water, as to make them ascend, shall be more fully treated of hereafter, when we come to consider the Nature of Beasts, *&c.*

Now since most Fishes are of so wonderful a Structure, that they can and must make use of the Pressure of the Air, in order to remain under the Water, and in such Places as are most convenient for them, without being forced to Ascend or Descend against their Wills; and that all of them, without such a Pressure of the Air, being forced to the Top of the Water, would soon be destroyed; let us draw this Conclusion only here, That he must be a very strange Person that shall maintain, that the Air and its Pressure, so very necessary in this case, is produced upon the Earth by meer Accident, and without any view towards so useful an Operation; and that the Fishes are likewise formed casually, just after such a manner, as to be provided with Instruments by which they can increase or lessen the quantity of Air, for the aforemention'd Purposes.

SECT. XXXII. *Plants do also live by Air.*

THE Air is not only of such great Use to Men, Beasts, and Fishes, but even to Plants themselves, which vegetate thereby in such a manner, that a great part of the Sap with which they are nourish'd, is composed of it. Wherefore, in case Men could have lived even without Air, yet they could not have enjoyed sufficient Food from the Earth without it, because it contributes so much to the Fertility thereof, which is well known to the Husbandmen, who for that reason break up and plough their Lands so frequently, in order to expose them to the influence of the Air.

However, if what we have here said, be not clear nor intelligible enough to any one, namely, that Air insinuates itself into Plants, and that they cannot grow without it, they may consult those accurate Enquirers into the Nature of Plants, *Malpighi* and *Grew*, concerning the Air-Vessels which they have

have diſcover'd therein by the help of Microſcopes; and *Boyle* and *de Stair*, concerning their Obſervations with the Air-Pump: Theſe Gentlemen having ſhewn, that Air can be drawn out of Plants placed *in Vacuo*. But he that would have ocular Demonſtration thereof, let him take a little piece of a Twig from a growing Tree, or green Leaves cut aſunder, and other parts of Plants, and tie them to a Nail, or any other heavy Matter, and put them into a Glaſs in which there is *Lye* made of *Salt* of *Tartar*, or *Pot-aſhes*, in orto make them ſink down into it; then putting them all together under the Receiver of an Air-Pump, and exhauſting the Air out of the Receiver, he will preſently ſee the Air coming out of the Ends that were cut off from the Plants, in numberleſs Bubbles, and riſing up to the top of the *Lye*; at leaſt it happen'd ſo in all the Experiments which I have had occaſion to make in this Matter; and from ſome of them particularly, as from the Twig of an Elm-tree, I obſerv'd a much greater Stream of Air than can eaſily be believed by thoſe that had never ſeen the ſame.

The reaſon why we rather preſcribe the uſe of Lye than of Water in theſe Experiments, is, becauſe no Air will mix itſelf with the former, tho' it be never ſo long expoſed in an open Veſſel. You may uſe Water alſo, after you have boiled it ſo long, till all the Air be evaporated, and let it ſtand till it be cold again.

Can any one fancy that this is likewiſe accidental, and without Deſign, or believe that he owes no Thanks for this noble Benefit of the Air to the bountiful Giver of it? who has been graciouſly pleaſed to provide thereby not only for the Life of Man, but alſo for his Suſtenance and Food, which ſprings out of the Earth.

Sect. XXXIII. *Fire is maintained by Air.*

Add to what has been ſaid, that Air has this Property likewiſe beſides all the reſt, that Fire (which without all Contradiction, is one of the moſt uſeful things that is known to Man) cannot burn without Air; at leaſt, that kind of Fire that we commonly make uſe of: So that for want of Air, almoſt all Fire will be extinguiſhed *in Vacuo*, or in any Veſſels into which one puts live Coals, and cloſes them therein. Now how many Inconveniencies would befal the whole World, if we had not the uſe of this glorious Creature, but ſhould be bereaved of its Warmth in cold Weather, of its Light in Darkneſs, and of many other Advantages it brings along with it! But we ſhall ſay no more of it here, becauſe we deſign to treat of it more expreſly in our Diſcourſe upon that Element.

Sect. XXXIV. *Air cauſes Smoak, and the Particles thereof to aſcend*

This is certainly true, that if the Preſſure of the Air did not cauſe the Smoak of all things that are burnt with Fire, of all putrified and rotten Matters, and other diſagreeable Vapours perſpiring from ſolid or fluid Bodies, to mount up like Oyl in Water, the ſame would render the ſurrounding Air foul and unhealthy to us: And how would Mankind be refreſhed with that vaſt number of ſweet-ſcented Flowers and Plants, with lovely Perfumes and Spices,

if

if the Creator had not endowed the Air with a Property of conveying to the Instruments of Smelling, all those Exhalations which we endeavour to discover and enjoy by the help of that Sense?

Sect. XXXV. *Air is the Cause of Sounds.*

But that which shews in the plainest manner the Obligations of the Thankfulness we lye under to the Great Creator, is that those wonderful Instruments of Hearing, notwithstanding the most wise and artful Contrivance thereof, would have been implanted in Mankind and all other Living Creatures in vain, and without any manner of Advantage, unless the Air by its Motion had been endowed with a Power of producing Sounds: For how miserable all Men would have been without Sounds, and consequently without Hearing, has been already proved in our Contemplation upon the *Senses*.

Sect. XXXVI, *and* XXXVII. *Several Experiments to prove the Production of Sounds by the Air.*

It is not now our Purpose to enquire here what kind of Motion, or what Parts of the Air produce Sound: This seems to be certain, that it is a Motion of the Air's Elastick Particles; for upon exhausting these Elastick Parts of Air suddenly from the Glass Globe A (*Tab.* XIII. *Fig.* 4.) and upon their protruding one another towards the Space of the empty Pump, we could observe a Sound or Noise, which, when the Receiver was full of Air, and the Spring of the Air more strongly dilated, that is to say, at the beginning of it, is loudest, but upon evacuating the Receiver, and consequently upon weakening the said Spring, or perhaps also, upon lessening the number of the mov'd Parts, the Sound is gradually diminished.

Thus we find by hanging a little Bell within the Receiver, and pumping the Air out, the Sound of the Bell becomes much weaker. A Striking-Watch shut up in the Receiver of an Air-Pump, and fasten'd to a String, is not heard so plain as when it is out of the Bell; but upon exhausting the Air, the Sound was so much and so sensibly diminished, that it could scarce be heard at all. But as far as I could ever yet learn, no body has been able to exhaust the Air so far, as that the Sound of a Clock or Bell should not be heard at all; unless it were only Mr. *Huygens*, who in his *Traitté de la Lumiere*, *p.* 10. informs us, that he placed a Clock upon Feathers or Cotton, to the end that its tremulous Motion might not be communicated to the Glass in which it stood.

And it is likewise observed, that a Place in which the Elastick Power of the Air is much weaken'd, or made a *Vacuum* in the middle of the common Air, and an Opportunity afforded to the said Air, to be push'd in from all Parts thitherwards by its Elastick Force, so that its Parts strike against one another, a great Noise is caused thereby; for if you put the two Brass Hemispheres which are commonly made use of by those that use Air-Pumps, upon one another, and stopping them very close, pump the Air out of 'em, and so make the hollow Space therein to contain but very little Air, and that much weaken'd too; and if then those Hemispheres, or Half Globes, be suddenly

drawn asunder by a great Weight, and thereby an Opportunity given to the Parts of the external Air to strike against each other, we shall find a Noise produced thereby, like the Discharge of a Gun.

The same has been likewise remarked above, in the breaking of the Glass (*Tab.* XIII. *Fig.* 3.) by the swift forcing in of the Air into the Brass Vessel A B C D, out of which at K, there was some Part of its Air exhausted, and consequently the Elasticity of the remaining Part was weaken'd in Proportion. As it also happen'd, when instead of such a Brass Vessel, an octangular Half-Pint Bottle was placed upon the Mouth O, of the Brass Plate H I, and a little Air exhausted from the same, whereupon the Glass Bottle bursten into small Pieces with a loud Report by the Pressure of the external Air: To prevent any Danger from thence, the best way will be to cover the Bottle with a Bladder fasten'd about the Neck thereof.

Sect. XXXVIII. *Convictions from the foregoing Observations.*

We shall not here enquire farther what probable Conclusions may be deduced from these and other Experiments, concerning Bodies yielding Sounds by the particular Motion of the Parts of the Air; but this may be safely affirmed, that without Air, little or no Sound would result from the Motions of Bodies. Now can they that know the necessity thereof, maintain such a sort of Philosophy, as teaches that the Faculty with which the Air is endowed, of conveying Sounds and Smells to our Ears and Nostrils, is only owing to Chance, without any View of being serviceable to Mankind?

Sect. XXXIX. *The Use of Air in Pumps.*

Besides all these wonderful Uses and Services daily render'd by the Air to such as inhabit this Earth, a great many more might be mention'd: And ought not then every Body that has any Sense of Generosity, acknowledge how much he is bound to give thanks, when he, without contributing any thing thereto on his own Part, finds himself surrounded with so vast a Force and Pressure of the Air, which he can make use of according to his own Pleasure, in so many Occasions for his Conveniency, and to avoid being troublesome to himself or others?

Every one who knows that Pumps, Syringes and Fountains, and such like Hydraulick Instruments, are only render'd useful by the Pressure, that is by the Gravitating and Expansive Power of the Air, which, by the Art of Man, has been applied thereto, will be fully convinced of the Truth of this Proposition.

And those who are ignorant of it, may consider the Spout or Syringe, A B C, *Tab.* III. *Fig.* 3. (of which mention has been made above in *Contemplation* VII. §. XI.) as a Barrel of a Pump standing in the Water D C E; in which Pump, as has been there shewn, no Water will ever ascend, tho' you should draw the Piston F upwards, unless the Air G do gravitate upon the Water D E. Now, that a Pump on this occasion may be look'd upon as a kind of Syringe, is known to every Body.

Sect.

SECT. XL. *The Air hinders fermenting Liquors from flying out of the Vessels that contain them.*

THAT there are so many fermenting Liquors, such as Beer, Wines, *&c.* working in themselves, used by several Nations for their Pleasure, Refreshment, and other Ends, we ought thankfully to confess to be owing to the Goodness of our Creator; who, by placing the Air upon this Globe, and endowing it with a Gravitating and Elastick Faculty, causes those Liquors to stay and remain within their Vessels, which, without such a Pressure of the Air, they would burst to pieces, or run all out of the Mouth thereof. They that have a mind to make a Trial of it, let them take a Glass of our common Beer, that has done working, and is some Days old; let them place it in the Receiver of an Air-Pump, and exhausting the Air, they will presently see it rise and froth, and run over the Brims of the Glass like Bottled Beer: but by letting in a little Air again, it will presently subside, and cease frothing and working.

To take no notice, that unless the Pressure of the Air did put a stop to such Working, the Drink would immediately lose both its Strength and Agreeableness, as every body knows that has tasted Beer after such working in the Air-Pump, whereby it is rendered as flat and insipid, as if it had stood a great while exposed to the open Air.

The good Wives ought likewise to be informed, that without this Pressure of the Air, no boiling Water wou'd stay in their Pots and Kettles. They that doubt thereof, let them set a little Tea-cup full of hot Water under the Receiver of an Air-Pump, then draw off the gravitating Air, and they will find that the Water will run over and dilate itself almost like Gun-powder that is set on Fire.

SECT. XLI. *Refraction and Twilight, or Break of Day.*

NOW as most of the Effects we have already mention'd concerning the Air, are produced by the Gravity and Elasticity thereof; altho' towards the Respiration of living Creatures, towards fertilizing the Earth, and perhaps too towards the Nourishment of Plants, and other Matters which are brought to pass by the Air, there seem likewise to be some other Faculties and Parts requisite in the same; I say, besides all this, it does yet render one eminent piece of Service to the whole World, and that upon account of being composed of a fluid Matter, denser than that which is above it, *viz.* that by the *Refraction* or breaking the Rays of the Sun in the said Air, the *Twilight* of Morning and Evening are produced; whereby a clear and full Day is prevented from being turned oftentimes in a very little time into a Night as dark as Pitch in the Evening, and so again a dark Night from being turned all at once into a bright Day, to the visible Prejudice and Weakening the Eyes of Men, and all other Creatures; it being sufficiently known to all that have tried it, how troublesome and inconvenient are such great and sudden Changes, from thick Darkness to a strong and clear Light.

'Tis owing to this Property of the Air, that the Countries which lie near the Poles, during their long and diſmal Nights, do participate of the comfortable Light of the Sun many Days before it riſes above the Horizon: From hence it proceeds likewiſe, that thoſe Nations which lie far from the Poles, and in which the Sun daily riſes and ſets, do diſcover ſooner, and are deprived later of the welcome Light of Day, which they therefore enjoy much longer than if there had been no ſuch thing as Air about this Globe of the Earth.

To give the Reader ſome Notion thereof; ſuppoſe N Z S, to be the Globe of the Earth in *Tab.* XIV. *Fig.* 3. E W H T, the Air ſurrounded it, and E Y, the viſible Horizon of thoſe People that dwell at F: Now the Sun would be inviſible as ſoon as it was got below this Horizon, if there were not between the Air and the Sun at A, ſuch a denſe Subſtance as the Air it ſelf, which the Ray of the Sun A H falls upon; and Mathematicians know, that it muſt be conſidered as if it fell upon the Line B C, which touches the Air at H; this Ray therefore falls obliquely upon the Air, as making with the Line B C the Angle A H C.

Now it has been ſhewn above, when we treated about the *Sight*, in *Contemplation* XIII. That a Ray (*Tab.* X. *Fig.* 2.) coming upon a denſer Matter, which is likewiſe tranſparent, does not run ſtreight forwards to D, but is inflected towards the Perpendicular G Q; that is, being bent or refracted at H, is diverted into another Courſe H F; ſo that in *Tab.* XIV. *Fig.* 3. this Ray of the Sun A H, by ſuch an Inflection, may reach the Eye of one that ſtands at F, whereas it would otherwiſe have paſſed a great way above him at D.

It is likewiſe plain by Optical Experiments, that a Ray, according to the Right Line H F, falling upon the Eye, the Perſon that ſees, does always fancy to himſelf that the Object is in the Ray F H; for which reaſon the Sun A, being really under the Horizon E F Y, they that live at F, think that they ſee the ſame in the Line F H, produced, that is at R, and above the Horizon.

Now that this is ſo, has been briefly ſhewn above in *Contemplation* XII. *Tab.* X. *Fig.* 4. and from thence it may in ſome manner be comparatively known, how the Rays of the Sun, being refracted in the Morning and Evening Twilights, do enlighten the Earth, and cauſe us to ſee the Sun before it be really riſen, and after it is ſet.

Sect. XLII. *Convictions from the foregoing Obſervations.*

Now can the unhappy Atheiſt fancy again, that this Property of the Air, with reſpect to Light, is likewiſe produced accidentally? Whereas he is nevertheleſs forced to acknowledge, that it is ſo great a Benefit to himſelf, and the reſt of the Inhabitants of the World, that in caſe he had the ordering of it himſelf, he would think that the Advantage which he had acquired from this one Property of the Air, was alone worth the while to encompaſs the Earth with ſuch a Body.

TAB. XIII

Fig. 2

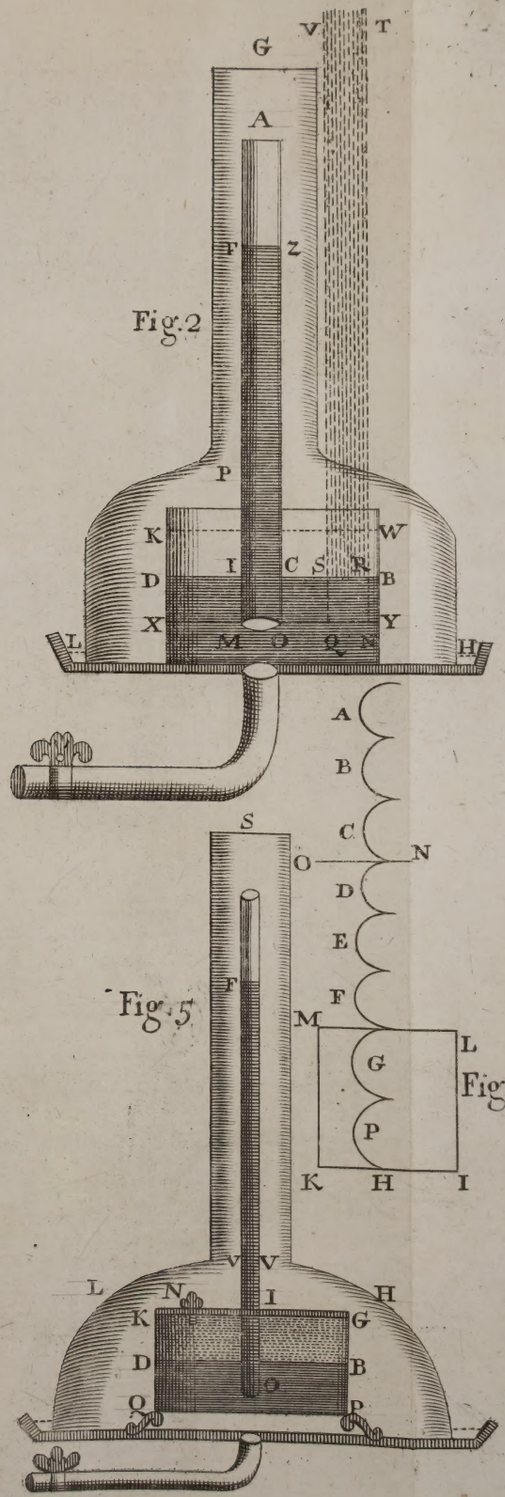


Fig. 5

Fig. 6

Fig 3

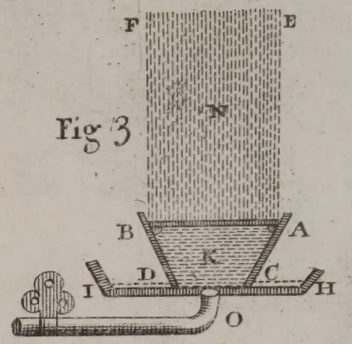


Fig. 1

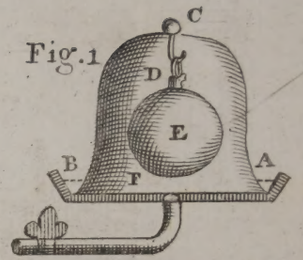
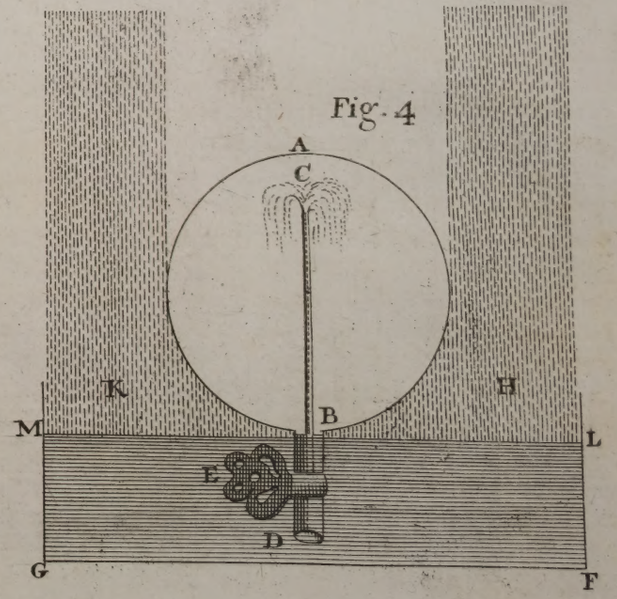


Fig. 4



SECT. XLIII. *The Gravity and Elasticity of the Air unknown to the Ancients.*

BEFORE I quit this Subject, I cannot forbear saying something very remarkable for the Comfort and Confirmation of such as have not so far forgotten GOD, as to deny the Perfections and Attributes of that adorable Being, by whom all things have been produced: Let such therefore consider, that the Gravity and Elasticity too of the Air, are new Discoveries, being accordingly so term'd by the Gentlemen of *the Royal* French *Academy, in their History for the Year* 1702, *of the first Discoveries made by Modern Philosophy about the Nature of Light*, that they were unknown for so many thousand Years to the most diligent Enquirers into Nature, and continued a perfect Secret, even to the most learned Philosophers, till the last Age. For they, and all the Ancients, look'd upon the Air to be a light Body, which would ascend of itself, at least, that it was without Gravity or Weight, to speak of that Property in the first Place, till in the last Age, the Invention of *Barometers*, together with the subsequent Experiments made by the Air-Pump, Fire, and otherwise, did furnish us with undeniable Proofs, that the Air is a heavy Body, and that we are able to compute the Weight thereof. Add to this, that the *Barometer*, (the first Instrument that has given Men a Notion of this Gravity of the Air) was not discover'd either by the Study or penetrating Judgment of the Inventer, *Torricellius*, who had not this in his View, by any means; but (to use the Words of Mr. *de Stair, Physiolog. Expl.* XIX. *Sect.* 41.) was revealed by the Divine Providence in the Year 1643, and as to him, entirely beyond his Expectation.

CONTEMPLATION XVIII.

Of Meteors.

SECT. I. *Transition to the Meteors.*

BEFORE we take leave of the Air, it seems requisite to say something concerning *Meteors*, such as the *Clouds*, *Mists* or *Fogs*, *Wind*, *Rain*, *Thunder*, *Lightning*, &c. forasmuch as an infinite Number of Wonders have at all times appeared therein; and the Almighty has thereby, in a particular manner, manifested his Tremendous Power and Greatness many times to those who, as far as in them lay, endeavour'd to deny it; and forc'd them to own it with Fear and Trembling: Yet, forasmuch as the same are mostly placed out of the reach of such Experiments as might serve either to make a just Enquiry into all the Causes thereof, or even to try the Certainty of some proba-

probable Opinions concerning them; Humane Knowledge does not extend itself far enough in these Matters to be able to say, with sufficient Certainty, how they are produced, and how they operate.

Sect. II. *The Air is a Menstruum, or Dissolving Fluid.*

This seems however to be true, that the ambient Air has the same Power and Effects upon many Bodies, as that which the Chymists call a *Menstruum*, or dissolving Liquor; upon which it operates after the same manner as *Brandy*, for Instance, upon Spices put into it, out of which it extracts some of the Parts, and incorporates them with itself.

Sect. III. *The Air is impregnated with great variety of Particles.*

Thus we see, that all the *Effluvia*, or Exhalations of such an infinite number of Bodies; that all the Scents, whether of sweet or stinking Bodies, the Smoak and Steam of things that are burnt or putrified, the Vapours and Fogs arising from so many Seas, Rivers, Lakes, Ponds, and other Waters, the Particles of Fire from so many Flames of Nitrous and Sulphureous, of Acid and of Alcaline Bodies, or of both of them fermented together; in a word, whatever they call Volatile, and which being exhaled, can ascend, are all mixed with the Air, and collected in the same, as in a common Magazine or Ware-House. Add to all these the Rays and Light of the Sun, that move with so unconceivable a Swiftness, as we shall show hereafter, and which are reverberated, or do rebound back into the Air in infinite Streams and Numbers: To say nothing of the Planets and fix'd Stars, which how little Effect soever they may be supposed to produce, by reason of their vast Distance, yet, since these Heavenly Bodies are seen thro' the Air, and the Rays are transmitted from them with a prodigious Velocity quite thro' it down to us, we have reason enough not to pass them by in silence. To reckon every thing, would be impossible; and they who are never so little conversant in the Experiments of Natural Philosophy, will readily agree, that there is such mixture of an infinite number of different Particles.

Sect. IV. *The same proved in Sulphureous Particles.*

That we may give an imperfect Sketch thereof to such as are Ignorant and Unexperienced; and passing by those *Effluvia*, or Vapours, that rise from Water, as being too common; that Sulphureous Particles are mixed with the Air, may appear from the Scent or Smell of Brimstone that attends Lightning sometimes; besides that, several Accounts teach us, that they ascend from the *Volcano's*, or *Burning Mountains*, in vast Numbers, into which they are dissolved by the means of Subterraneous Fires, after the same manner as it is done in Chymical Operations: And this is also plain from hence, that even here in our watry Country, there are Pits or Wells over which if you hold a Candle, the Air will immediately be kindled; insomuch, that whole Houses have been consumed by the firing of such Steams; and not long

since, a Person was miserably burnt in that Country, which we call the *Beemster*, in *North-Holland*, which is nothing but a drained Meer or Lake.

Sect. V. *The like Mixture with Particles of Fire.*

That Fire mingles itself with Air, appears by many Experiments, such as Lightnings, as also that Matter which the Chymists call *Phosphorus*, which having lain many Years under Water, and being taken out from thence, immediately shines in the Dark, and with the least Warmth (even so small that it can hardly be called hot) it will burn so, as not to be extinguish'd. Such a *Phosphorus* is distilled from Humane Urine, after it has stood so long in the Air till it is corrupted: And some who have tried it, say, that in case such Urine can be kept where no Air can come at it, notwithstanding it be so chymically prepared, it will neither shine nor burn.

Sect. VI. *Alcali's and Acids mixed with Air.*

That *Volatile* and *Alcaline Salts*, such as those that are extracted from Soot, Harts-horn, *&c.* are dissolved in the Air, is well known to those who have smelt of the same, and have often learned to their Cost, that such Salts are in no wise to be preserved long; and Glass Phials filled with these Volatile Salts, and not well stop'd, have frequently been found quite empty, or at least have lost a good Part of them. The same has been observed as to Acid Liquors, by the sowre Smell that exhales from them, such as Vinegar and other things: Insomuch, that if you set any Acids under a Copper or Brass Plate, the Vapours that exhale from them, and mingle themselves with Air, will eat through such Plates, and turn them into Verdigrease. Moreover, in distilling Spirit of Salt-petre, which comes over without any Water, we know that all the Stopples that are used to the Phials that contain 'em, are corroded by the Particles that ascend into the Air; and that the said Spirits being put into an open Bottle, do frequently emit visible Effluvia.

Sect. VII. *Burning Spirits and Oils mix themselves with the Air.*

The Air is likewise impregnated with *Burning Spirits*. This is known to every Body that has warmed good Brandy, and held a burning Paper or Candle near the Steams of it; of which those that are in the Air are immediately kindled. The same Experiment is made by the Chymists in their Distillations, when they try whether their *Lutums* (that is the Matter which they apply to the Joints of their Vessels) are as close as they should be; for if one holds a Candle to them, and any of the Effluvia come out, those that pass into the Air through the *Lutum*, will immediately take Fire.

Oils themselves will mingle with the Air. Wherefore, to say nothing of Train-Oil, which can be smelt so far off (forasmuch as some may doubt whether they be the oleaginous Parts themselves that affect our Nostrils) let any one take Oil of Olives mingled with Salt, and distil it with a glowing Iron Pot, upon which there is an Iron Helm or Head, with an Orifice or Hole at the Top, so as it may be shut with an Iron Cover, he will find when the Cover is taken off, in order to take some of that Matter with an Iron Ladle

out

out of the Pot, and to put fresh therein, that the Steams (which being drawn over into the Recepient, do there make what they call an *Oleum Philosophorum*) as soon as they come into the Air, flame out, and so continue till the Orifice of the Helm be again closed.

SECT. VIII. *Other Particles do likewise mix themselves with Air.*

AN infinite Number of other Particles, besides those of which we have given Instances above, are found to incorporate themselves with the Air as with a common *Menstruum*, or Dissolvent; accordingly it is observed by *Varenius*, in his *Geography*, (*Lib.* I. *Cap.* XIX. §. 41.) that when the Spices in the *Indian* Islands are ripe, the Seamen know it by the Smell thereof, at the distance of three or four Leagues: That in the Islands named the *Azores*, the Air is impregnated with so many Acid Particles, that it corodes even the Iron and Stones of Houses, in such a manner, as to reduce them to Dust in a little time: whereas, on the contrary, in the Province of *Chili* in *America*, the Air is so soft, and that tho' one put up a Sword without cleaning it into the Scabbard, there will never be found any Rust upon it. They that would be further informed upon this Subject, may consult the Author in the place we have quoted.

SECT. IX. *Many Particles preserve their Properties in the Air.*

AFTER all this, no body I think will scruple to acknowledge the Air to be a Menstruum impregnated with an infinite Number of Particles; only it seems necessary before we proceed, to shew, *First*, That the Effluvia of such a great Number of solid and fluid Matters, tho' dissolv'd in the Air, may yet preserve the same Properties which they had before they were mingled therewith. They that desire sufficient Instances thereof, may see what that great Naturalist, Mr. *Robert Boyle*, has writ about them in his Discourse on the *Nature of Effluviums*. This, however, has been experimentally observed, first in fluid Matters, from a great many Distillations of Waters, of Burning Spirits, of Acid Spirits, of Spirits that have Volatile Salts in them, of Quicksilver, and almost all such like Liquors, which evaporating in the Air by Warmth, do therein so very much maintain their own Figure, that being admitted into a Recipient, and turned again into a Liquid Matter, almost all of them yield the same Fluid of which they were composed before they were mingled with the Air.

The same may likewise be observed in many solid Bodies, which the Chymists do raise, or (as they phrase it) sublimate by Fire. Thus, according to the Report of the aforesaid Mr. *Boyle*, who ought never to be named but with respect, *Sulphur*, *Camphire*, *Benjoin*, *Sal-Armoniac*, and even a Metal as heavy as *Tin*, may be sublimed and mix'd with the Air by the Heat of Fire; and the Parts thereof being coagulated, by meeting with Glass or some other Matter, may be again changed into a solid Body, with the same Properties it had before.

And let no Man imagine that we draw out this Analogy too far, because they are not sensible of such a Heat, or of such Fires in these Climates, as might

might seem sufficient to dissolve these Bodies, and to cause them to evaporate into the Air, to perform which, so intense a Heat is required in Chymistry: For whoever has read any thing concerning the Subterraneous Fires that shew themselves in burning Mountains, and with how much *Sulphur*, *Ashes*, and other Matters, they have often filled the Air, even at the remotest Places, will find that there is not the least room to doubt thereof.

SECT. X. *The aforementioned various Particles, by their operating upon each other, cause the Air to be Wholsome or Unwholsome.*

FROM what we have shewn already, it will follow, *Secondly*, that he who knows how variously and powerfully these Particles, floating in the Air, do operate upon each other, will easily conceive, that from the different Conjunctions and Separations thereof, different Qualities of the Air does likewise result. Insomuch that some of the Parts being wholly innocent in their own Nature, by their Conjunction and Mixture with each other, may become hurtful and even fatal; and so on the contrary, those that are prejudicial, may likewise become healthful, and thus in many Cases they may undergo many Changes.

SECT. XI, and XII. *Several Experiments to confirm this.*

THUS we see (to give an Instance of what we have asserted) that the Spirit of *Common Salt* and *Mercury*, neither of which are poisonous alone, being sublimated by Fire, are united in the Air, and then become such a deadly Poison (to which they usually give the name of *Sublimate*) that if it do not exceed *Arsenic* or *Ratsbane* itself, it may be counted at least as fatal. We shall not here enquire whether what has been observed by *Diemerbroek*, *de Peste*, Lib. II. Cap. 3. might be supposed to have happen'd after such a manner; namely, that the Fumes of *Soap* with which Linnen was washed, might have brought the Plague into the Houses of *Nimeguen*, and have render'd the Air of that Town contagious; tho' it is well known, that the Ingredients of which that Matter is composed, have nothing pestilential in them. This is hardly to be doubted, that when the Subterraneous Fires in the times of Earthquakes, have filled the Air with many Exhalations, those Exhalations themselves, or their Union and Co-operation upon other Particles of the Air, have often produced Contagious and other Epedimical Distempers.

Thus we also see that great and pernicious Poisons floating in the Air, being joined to other Matters, do thereby lose their pernicious Qualities. And the Chymists know very well, that how often soever the aforementioned Sublimate is exhaled or raised up into the Air, it will still remain a deadly Poison: But if one take an equal Weight of Salt of Tartar, and mix it therewith, and then evaporate both together, their Parts will unite themselves in the Air, and losing their poisonous Faculty, will produce a Medicine call'd *Mercurius Dulcis*, which is very good in many Cases. Some ascribe it to the same Cause, that the Plague ceases at *Grand Cairo* as soon as the River *Nile* begins to swell; so that whereas the very Day before there might die

500 Persons, the very next Day there would not perhaps die one, according to the Relation in *Sandy's Travels*, Lib. II. The above-mention'd Mr. *Boyle* confirms the same by many Instances.

That Gentleman has likewise taught us experimentally, that fluid Bodies may be changed into solid ones in the Air; for example, mix the Spirit of corrupted or fermented Urin with Brandy, which has not been entirely separated from its Water; and setting it over the Flame of a Lamp, or some other more gentle Heat, the Fumes ascending from thence will be turned into a solid Body in the Air, appearing at the Top of the Glass like a fine white *Sublimate*, notwithstanding that before the Distillation each of them was a liquid Matter.

It is not our Design in this place to enquire so strictly, whether the abovementioned Phænomena at *Nimeguen* and *Cairo*, were rather to be ascrib'd to a Precipitation or Coagulation, which some of the ascending Particles might produce in the Air; but that something of the like nature may happen in the Air, whether by Conjunction or Separation, seems to be maintainable in some manner, from the Observation of the Professor *Schagt*, at the time of the Sickness at *Leyden*, of which mention has been made before in *Contemplation* VII. and that which has been related to me by a curious and observing Gentleman, seems to confirm the said Opinion, which he says was commonly known to all the Inhabitants of *London* at that time, namely, that in the dreadful Pestilence of the Year 1665, those *Coffee-houses* that were continually filled with the *Smoak* of *Tobacco*, were almost the only places that escaped the Infection.

I shall not pretend to determine, whether what we have just now mention'd must be understood to happen after the same manner, as when a good quantity of *Sublimate* is dissolved in Water, and when into the same Liquor, which is very poisonous, Salt of *Tartar*, likewise dissolved in Water, is poured, so long, till a reddish Powder is produced and sinks down to the Bottom, or, according to the Chymical Term, is *precipitated*; after which it will appear, that by the Operation of these two Matters upon each other, all the Poison of the *Sublimate* will be done away: Or, whether it may be supposed to happen in Conformity to that other Experiment, and the Consequences thereof, in making of *Mercurius Dulcis*, as has been observed above. Our main Design in all this, has been only to shew, that upon considering the whole Matter, we ought to suppose this Globe of Earth, with its ambient Air, not only to be a Mathematical Machine (which may be proved by other Experiments) but even a great *Chymical Laboratory*, in which the Air represents a Recipient, in which thousands of Kinds and Differences of exhaling Particles are collected, either by Subterraneous Fires, by the Heat of the Sun, or by some other Causes; or otherwise, as a *Menstruum* and Dissolvent, which being poured out upon innumerable Matters, extracts and unites to it self various Particles from each of them: And those Particles being mingled with the Air, may variously operate upon each other, according to their different Natures and Properties.

SECT. XIII. *Convictions from the foregoing Observations.*

BEFORE we proceed any further, in case any body, be he who he will, that has formed a just Notion of this Constitution of the Air from what has been said already, and knows what an infinite Number, not only of the same, but even of different Kinds of Particles, do occur in the Air; after how many various manners they unite with each other; how from their Conjunction, from their Division or Separation, and otherwise, so many pernicious and fatal, as well as wholesome and useful Effects may result; I say, if besides all this, he is assured, that without Air neither Animals will live, nor Plants grow; Can he sit down easie under a Perswasion, that all things do thus come to pass either by Chance, or by Mechanical Causes, entirely ignorant of what they are doing, and without any Wisdom or Design? And that without an infinite over ruling Power and Providence, this real *Chaos*, or confused Mass, subject to such an unspeakable number of Alterations, by the multitude and disagreeing Properties of its Parts, could have been adapted for so long a Time, and still continue so to preserve alive so many thousand Animals and Plants, and to furnish all that is particularly necessary to every one of them, with so vast a Variety? And can he imagine, that it is to be ascribed to any thing but a Divine Direction, surpassing all Understanding, that these things do not fall into the utmost Confusion? Yea, can he possibly, with all his Wisdom, form any just Idea thereof? How from such a confused Mixture of all kinds of things as the Air is, and among which many indeed are serviceable and useful, but likewise many others, both prejudicial and even contagious and fatal; I say, that each requisite Particle can discharge its Function in its Place, and all the bad ones be prevented from doing harm, were it not that the Supreme Will of our adorable Ruler did herein exert its Wisdom and Power.

SECT. XIV. *The Invisibility and Insipidity of the Air very useful.*

THE aforesaid Wisdom and Goodness of GOD has often occurr'd to me with great Astonishment, when I considered, that He has been pleased to subject to our Sense of Seeing, *Fire*, *Water*, *Earth*, *Sun*, *Moon*, *Stars*, and almost all other Creatures, excepting only the Air, which though we can feel well enough in Winds, and other Cases, yet He has thought fit to render invisible to us. And yet, how does almost every Man tremble, when he sees the Vapours and other active Particles therein, gathered together in dark Clouds, and threatning us with Thunder and Lightning, with Storms and Tempests?

Again, If any one should be obliged to drink the Waters of *Fens* and *Marshes*, of *Ditches* and *Kennels*, mixt with Dirt and Nastiness, tho' perhaps not otherwise pernicious, how loathsome would it appear to him? Or if he should meet in it any of the *Spawn* of *Serpents* or *Toads*, tho' there were not enough thereof to poison him, yet with how much Fear and Terror would he take the Cup into his Hands? And what pains would he take to separate what was pure and wholesome from this dreadful Composition? Now, if in

the ſame manner, all the Filthineſs that is to be found in the Air, all the exhaling Particles, from foul and naſty Places, all the Vapours from ſtinking Puddles, or from rotten Carrion, or dead Carkaſſes, all the aſcending Steams from poiſonous Minerals, and contagious Animals or Plants, all the diſagreeable Effluvia from the Bodies of Men and Beaſts, and whatever elſe of other Infections in the Air might be added hereto; I ſay, if all things were ſet before his Eyes in the ſame manner, would he not loath and nauſeate the very ſight of them? The ſame would certainly befal him, if he were capable of ſeeing with his Eyes the Air that he muſt conſtantly breath, fill'd with ſo many impure and unwholeſome Particles; would he not live in a continual fear of being poiſon'd by them? Would he not employ all the Powers of his Mind, even till he was tired, to find, if it were poſſible, among ſuch a loathſome heap of diſagreeable things, ſomething that was clean, and could be ſuckt in without nauſeating? Should we not ſee Rich Men offering more Money for Places where the Air was pure and wholeſome, than they now beſtow for ſtately Houſes and Country Seats? Now it has pleaſed the Gracious Director of all things ſo carefully to provide againſt theſe Inconveniences (that what befals us every Moment of our whole Lives, namely, the *Inſpiration* and *Expiration* of Air, might be perform'd with Pleaſure, or, at leaſt, without producing in us any diſagreeable Senſations) as to render inviſible to us that Air which would otherwiſe ſet before our Eyes a perpetual Swarm of deteſtable Objects; and by this means only (tho' they ſhould not be dangerous to our Health or Life) releaſe us from inceſſant Cares and Fears, of drawing into the Lungs by the Mouth and Wind-Pipe ſuch a quantity of odious things.

The like Averſion and Dread of ſo many Particles floating in the Air would befal us, but in a much higher degree, if they ſhould become ſenſible to our Taſt. Ought not then every Man to acknowledge his Obligations to the Wiſdom and Mercy of the Great Ruler of this World? Who, tho' he cauſes us to *hear* this compounded Air in *Flutes* and *Organs*, to *feel* it in *Winds* and *Storms*, and to *ſmell* it too in many Caſes; yet, that He might not make us miſerable, has form'd it after ſuch a manner, that notwithſtanding its being impregnated and laden with ſuch a Diverſity of Parts, it can be neither *ſeen* nor *taſted*, except in ſome particular and very rare Caſes; by which an Atheiſt may be convinced, that He who brings this about, does it of his free Will and Pleaſure; but by no means can it be ſaid to be thus order'd by neceſſary Conſequences, and much leſs by Chance. Accordingly we find, for Inſtance, that when an Apothecary has pounded a good quantity of *Aloes*, and that the fineſt Parts thereof fly up, and mingle themſelves with the Air, their Bitterneſs diſcover itſelf to the Taſt of thoſe that ſuck in that Air: And to ſhew, that the Air is likewiſe in its own Nature viſible, we need only compreſs a good quantity thereof together in an Air-Pump, and then let it out again as quick as we can, and it will preſently ſhew itſelf to our Eyes like a *Fog* or *Miſt*.

SECT. XV. *The Observations of Meteors resumed.*

BUT to return to the *Meteors*: If we should attempt to shew the Causes thereof fully and clearly, we must do it by a number of Natural and Chymical Experiments, which might be render'd Analagous and Uniform to the same in Little: But this would engage us in too large a Field; we shall however produce some few, to shew how the same are generated in the Air, without pretending that they may not come to pass many other ways; for as some of these, that are now known to us, were hid from the Ancients, so perhaps some may be discover'd by our Posterity, of which we are hitherto ignorant.

SECT. XVI, and XVII. *Mists and Fogs produced by many Exhalations, and by the Rarefaction of the Air, shewn Experimentally.*

TO say something first of *Mists* and *Fogs*: It is plain from what has been said, that unspeakable Numbers of watry Vapours and other Exhalations do mingle themselves with Air, by which they render it Thick and Untransparent or Dark: As first, when they arise in too great a Quantity, and are so closely compressed together, as to fill the Air, and to obstruct a free Passage of Light. In the same manner we see in Chambers, where the Smoak does not go directly up the Chimneys, as also by the thick Steams of boiling Water in Kettles, the Air render'd in some manner untransparent and foggy: The same happens by the numerous Vapours that arise in cold Weather in Winter, and here in *Holland*, upon the Breaking and Opening the Ice.

The second way of producing Fogs and Vapours is, when the Air is more rarified than usual, and thereupon becoming lighter, is no longer able to balance the more heavy watry Vapours, and to keep them floating in its own Region. A plain Instance thereof we may see in *Tab.* XIV. *Fig.* 5. by taking some of the Water out of the Glass Globe A B (from whence the Air was first exhausted, in order to fill it by the spouting in of Water, as has been shewn before on another Account in *Contemplation* XVII.) and then fastening or screwing it on to the Air Pump at D, so that the very small quantity of Air that remain'd in it at S, will appear above the Water N P R; after which, a *Vacuum* being made in the Pump, the Cocks E and K must be open'd; by which means the Air, which at S gravitated upon the Water N P, meeting with no Resistance, will drive it down towards the Pump, and so the Space A N P, becoming larger, the Air that is in it will be likewise more expanded or rarified. Now, as it does also become lighter thereby, the watry Vapours in it will sink down, and produce a visible and whitish Fog in the Globe, and many times little Clouds, exactly mimicking those that we see in the open Air. But these Mists and Clouds, upon the Re-admission of the Air Q W R thro' the Water, and by the Encrease and Compression of the Air at S, do immediately disappear again, and the said Air at S, as soon recovers its former Transparency; and so, *toties quoties*, becomes foggy and cloudy when it has an Opportunity of dilating itself and of forcing the Water out of the Globe, upon exhausting the Air; and again becomes

becomes clear and tranſparent, upon the letting in of freſh Air: So that clear and foggy Weather may be as alternately repreſented as often as you pleaſe after this manner; and even when there remain watry Vapours enough in the Air, this may be ſtill produced, provided the Bubble be but a little moiſt within, tho' altogether empty of Water.

SECT. XVIII. *Reflections and Obſervations upon the ſame.*

WE have made theſe Experiments very frequently, and from thence obſerv'd; *Firſt*, that theſe Vapours, when the Air appear'd heavy in a Barometer, were not ſeen at the firſt Pumping, nor did ſhew themſelves ſooner, till after ſome Expanſions of the included Air, it became lighter and thinner. *Secondly*, This Experiment did not ſucceed well when the Water and Air were cool; probably, becauſe there were not watry Vapours enough mixed with the Air: Wherefore hot Water, in a little Glaſs Veſſel (*Tab.* XIV. *Fig.* 4.) M N, being placed under the Bell, preſently fill'd the Air with the Steams which exhaled from it; but upon the admiſſion of freſh Air, vaniſhed as before.

It was likewiſe obſerved at another time, that no Miſt appearing in the Glaſs Globe in cold Weather, upon making a Fire in the Room, and the Air in a Thermometer ſhewing itſelf warmer, we renewed our Pumping a little while after, and the Fog became immediately viſible. *Thirdly*, We found likewiſe, that the Miſt which had been thus produced in the Glaſs, ſubſided by degrees, and the Glaſs became clearer, without admitting freſh Air into it. As alſo, *Fourthly*, That theſe Miſts, by letting in freſh Air upon them, and by the Wind which the ſame produced, being put into Motion, occaſion'd an agreeable Repreſentation of the irregular Courſe of the *Clouds* in the Air in the time of *Storms* and *Tempeſts*.

I have related this Experiment ſomething the more particularly, becauſe it did not always ſucceed, and foraſmuch as it ſeem'd to give us a great deal of Light into the Nature of *Miſts* and *Clouds*.

Now that the Natural Miſts, and Fogs, and Clouds are of the ſame kind with theſe Artificial ones, ſeems deducible from hence, that moſt commonly when the Air loſes its Clearneſs, and becomes more dark and obſcure, the Mercury in the Barometers deſcends, and ſhews thereby, that the Air is become lighter.

I have likewiſe often obſerved with Aſtoniſhment, that when the Air appeared clear all above and round about us, in a very ſhort time after, the whole Heavens grew dark and were cover'd over with Clouds. Whether this may be deduced from a ſudden thinning of the Air (becauſe we know of no other Reaſon beſides, that in ſo little a ſpace of Time can operate ſo quick over the whole Face of the Heavens) I leave to others. The Barometer may be compared therewith.

SECT. XIX. *An Experiment to prove that Miſts and Fogs may be produced by Effervеſcences.*

Thirdly, Another Manner by which the Air may be render'd foggy, will appear by an Experiment made with two little Glaſſes or Phials, containing

an Ounce each; one of which being almost filled with Spirit of *Salt-petre*, or *Aqua-fortis*, or else with Spirit of Common *Salt*, and t'other with that of *Sal Armoniac*; put the Mouths of both the Bottles near to each other, and you will find, that the Exhalations of both being mingled in the Air, will produce a visible Smoak or Mist, which, if the Bottles be placed far enough asunder, cannot be observed in either of them.

Now that this way of *Effervescence*, as the *Chymists* call it, is brought about by the reciprocal Action of their Particles in the Air, will be readily allowed by any one that ever saw the Effervescence or Fermentation that is caused by pouring one of these Liquors upon the other.

SECT. XX. *An Experiment proving the like Effect by Precipitations or Separations.*

Fourthly, WE learn another Way from *Chymistry* of turning clear and transparent Liquors oftentimes into a thick and troubled Matter, by Separation or Precipitation: Thus Sublimate or Vitriol dissolved in Water, and filtrated thro' a Paper, does yield a clear Liquor; but pour into it either Salt of *Tartar* or *Potash*, likewise deluted in Water, both of which are transparent, and you will presently see some Parts of the first Liquor precipitated or separated from the rest; by which means the Liquors will lose their Clearness, and be changed into a dark and thick Substance.

Whether this has also place in some of those that People call *Stinking Fogs*, I shall not enquire any farther here; this is certain, that those Stenches have often a great affinity with that which we discover in making *Milk of Sulphur*, or the *Golden Sulphur* from Antimony.

To prepare the last, they use to boil in Water the Sulphur of the *Regulus* of *Antimony* mingled with Salt of *Tartar* in the Fire, and to filtrate the same thro' a Paper, so that there proceeds from it a clear Liquor of a reddish Colour, and without any Smell; but putting in some drops of Vinegar, a grievous Stench arises from it, and the Liquors become thick and untransparent, until there subsides from it an Orange Colour and Yellowish Powder, which is the *Golden Powder*, and then both the Liquors become clear again.

I have often thought with myself, whether there were not something like this in the Air, which by way of Precipitation might produce those Stinking Fogs; *First*, by reason of the likeness of the Scent; and *Secondly*, because I have oftentimes observed, upon the Days succeeding these Fogs, a Reddish or Orange Colour Scum, very like that of the above-mention'd Golden Sulphur, upon standing Waters; which before those Fogs happen'd, were not to be found there. But I leave all this to further Enquiries.

SECT. XXI. *Fogs are Clouds.*

AFTER having treated of Foggy and Misty Airs, it does not seem necessary to say any thing more about Clouds; because it is very credible, that what we call here below Mists and Fogs, when raised up higher in the Air, do compose the Matter of Clouds; insomuch, that a Cloud is nothing but an exalted Fog. Now that this is something more than a bare Supposition, appears from Experimental Trials made by many People, who having climbed

up

up high Mountains, met with thick Fogs in their way; but when they were arrived to the Top, they observed the same floating under them like great and white Clouds. *Varenus* gives us a particular Relation thereof in his *Geography*, *Lib.* I. *cap.* 19. §. 41.

The same is asserted by that great Examiner of Nature, Mr. *Mariotte*, in his Discourse *Du Movement des Eaux*, *p.* 19. That climbing up a Mountain, at one place he was in the middle of a Fog, which whilst he was below at the Foot of the same Mountain, appear'd to him like a Cloud.

Another common Experiment may be made, when Gunners are trying their Cannon, by discharging several Pieces at once: Now every one knows that the Smoak thereof seems to those that are under it like a Mist in the Air; and so it appeared to me and others that were in the Boat with me, between *Amsterdam* and *Buikslot*, like a black Cloud driving softly on; especially, after it was carried by a gentle Wind, that did not scatter it, to a good distance from the place where it was discharged, and raised up higher in the Air. So that likewise it seems deducible from hence, that it is not always Watry Vapours, but also other Particles and Exhalations of which the Clouds are composed: Concerning which, as also of the Rains and Dews proceeding from the same, and other Meteors properly belonging to Water, something more subservient to our Design shall be mention'd hereafter in our *Contemplation upon Water*. To proceed.

Sect. XXII. *Wind, and its Usefulness, and Convictions from thence.*

Among the most common, but not the least wonderful, Motions of the Air, *Wind* has the principal place. Now it is known to every one, that the Wind is a Flood or a Stream of mov'd Air, insomuch that it wants no farther Proof after so many Experiments; only let us observe here first in general, that it is something, which after a very sublime manner, shews the Power and Goodness of the Great Creator.

They that have ever read of, or tried the dreadful Force of Storms and Tempests, of *Hurricanes* and *Travadoes*, will be sufficiently convinced of the resistless Power of the Wind. But Custom makes us contemplate this great Wonder without any Emotion. But if there should be still any one so wretched as not to learn his Obligations of Thankfulness to the Great Giver of all Things from these his Works, let him for once suppose with us, that there was no such thing in the World as Wind or Motion of Air, but that it remained in a perpetual Stagnation quite round the Globe, like a Pond or Lake of thin and dead Water: Must he not then own,

First, In case that what was raised up in the Air should remain in the same place, without being carried elsewhere, or so long at least, till it grew lighter, and so ascended; or heavier, and then descended, (to say nothing of Cities and Countries, which after Earthquakes might be visited with sad and fatal Distempers, by the Corruption of the Air) that great Trading Towns and Populous Places, where the Smoak of so many Fires of Coal, Turf or Wood, the Vapours of so many stagnating Waters, the Stench of so many impure Places, and thousands of other kinds of Exhalations proceeding from Men, Beasts,

Beasts, *&c.* did continually and incessantly fill the Air; and the whole World too, would soon be one universal Church-yard and Burying-place; for all its Inhabitants wou'd soon perish, were it not that by the help of these Winds, so exceeding necessary towards the support of all Living Creatures, fresh Air is continually derived to them from the Hills, and other healthy Places round about them; and the unwholsome and infectious Vapours driven from thence, and dissipated in the vast Space of the Skies. And can he that observes all this, perswade himself to believe that Winds are meerly accidental, and that he owes no Thanks for this great Benefit to him that made the Winds.

Secondly, If this is not enough to convince an Atheist, yet he certainly knows, that if the Vapours drawn from Water were to fall down in the same Place from whence the Sun had raised them up, most of 'em being exhaled from the Sea, would likewise fall down into it again; and that the dry Land, Fruit-Trees, and Plants, would never be able to share in their Moisture. Moreover, the Course of Rivers running from Inland Countries and Regions remote from the Sea, into which at last they discharge themselves, would likewise in time be partly or wholly dried up: Insomuch that Dews, Rains, and Inundations of Rivers, that render the Earth fruitful, failing altogether, would make it at last unfit to feed and keep alive, by its Productions, Men and other Creatures that dwell upon it.

Now this entire Destruction of almost all that breaths upon the Earth, is solely prevented by the Winds: By Means of which those watry Vapours, that do mostly arise from the Sea, are carried to dry Places, that they may there descend in Rains, Dews, Snows, and other Meteors, and supply for the most part the refreshing Streams of Brooks and Rivers with continual new Matter.

Now if so many Men, so many Beasts, so many Birds, so many Fishes, and so many thousands of Trees and Plants, were made without Wisdom and Design: Can any one say, without the Contradiction of his Conscience, that the Winds, for want of which all of them would in a little time perish by the Failure of their Sustenance, are thus made accidentally and without any determinate Purpose of our Great Preserver? Would he ever dare to assert the same of so inconsiderable an Instrument as even a Watering-Pot, wherewith we refresh the Plants and Flowers of our Gardens? And seeing that such a thing was adapted to convey a little Water from some adjacent Well, or Brook, into a Garden, and there regularly to sprinkle the Parts thereof; would he dare to maintain, that even such a contemptible Vessel was made without any Design of the Artificer? But if not, how can he expect to pass for a rational Creature, when he pretends to believe the same of the Winds, those great Aquæducts and Watering-Pots of the whole Earth, and for that reason the Preservers of his own Life, and that of all other Creatures?

Thirdly, Now to pass by the Obligations under which those Men lye, that make such great use of the Powers of the Winds to their Advantage and Pleasure both; so that where there are Rivers to turn Mills, they can apply these Streams of Air to the same Purpose: Can it be imagined, that

the ſaid Winds are produced accidentally, when without their Aſſiſtance the Inhabitants of the World could reap no Benefit from any of thoſe Countries that are ſeparated from them by great Seas, nor enjoy any Communication therewith?

If ſuch Powers of the Wind, (by which great and heavy Ships are convey'd ſo ſwiftly from one Part of the World to another; by which ſuch great Machines can be moved as ſhall ſuffice, with the Care of a few Men, to drain and keep dry ſo many watry Lands, to ſaw and prepare ſo much Wood for Building) could be bought or hired with Money; Can any one believe, that beſides the Merchants, almoſt every Body in the World would not be ready to contribute their Share, and to pay their Quota, that they might likewiſe partake of the good Things of other Countries, and of the beneficial Effects of Ships and Mills? Now the moſt Gracious Ruler and Preſerver of all Things does hold this great and uſeful Power, the Wind, in continual Readineſs for every Man that will embrace the Advantage of it, even for nothing, and without expecting any other Return than Thankfulneſs: And all this he vouchſafes to do, that he may diſplay his Wonders even to his Enemies themſelves, by a Matter that is inviſible; inſomuch, that if one had always liv'd in a place where the uſe of the Wind was never known, he could hardly be induced by the ſtrongeſt Arguments to give any credit to ſuch a ſtrange and unconceivable thing.

And can then an Atheiſt ſit down contented, when he not only refuſes to acknowledge this Benefit (but even blaſphemouſly denies with his Mouth the great Giver of all thoſe things, and if it were poſſible, wou'd moſt ungratefully blot him out of his Heart alſo) which, by the Adminiſtration of theſe Winds, happen to the Advantage of himſelf and all Mankind? Certainly, if the Winds were produced by no other Cauſes than mere Chance, operating now this way and then another, ſuch a Man ought to be in a continual Fear, that the Air would become fatal and peſtilential; by ſtagnating and putrifying, and the whole Earth a Wilderneſs for want of Rain, and that he himſelf and all Living Creatures would periſh by Hunger and Thirſt: And if the Winds were not beſtowed upon Mankind as a Token of the Mercy of its Creator, might not he himſelf draw this Conſequence, that he could not be able to eſcape the Power that exerts its ſelf ſo terribly in the Winds, and at ſome time or other he would moſt juſtly feel the Effects thereof, as a Puniſhment for theſe his Blaſphemies?

Sect. XXIII. *The Trade Winds and Monſoons*

It muſt indeed be allowed, That if there be any thing in the World that theſe miſerable Philoſophers may, with an Appearance of Truth, pretend to be accidental, it is the Wind, eſpecially after the manner that it moves and blows in theſe Countries; inſomuch, that it even gives a Handle to that Proverb, by which, if one would expreſs in the ſtrongeſt manner the Inconſtancy and Fickleneſs of another, we ſay, he is *as Changeable as the Wind.* But to convince them, that even the Winds are far from being governed by a mere and variable Chance; let them enquire into the Experiments

riments of Sea-faring People; and they will ſee (and if GOD be gracious enough to them, they will likewiſe be convinced) that the Providence of the Great Governour has bound theſe Winds, which ſeem to us to come from all Corners of the World with ſo much Irregularity and Uncertainty, by as fixed and determinate Laws, as ever any Clock or Watch made by its Artificer.

But not to ſpeak any thing more in Confirmation of what we have now ſaid concerning thoſe Land and Sea Winds, which, vibrating like the Pendulum of a Clock, do every four and twenty Hours blow backwards and forwards upon certain Coaſts, without which many Countries would not be able to ſubſiſt, nor many Voyages be made ſafely and conveniently; there are beſides the changeable Winds that govern in our, and other Parts of the World, two principal and well known Kinds of regular Minds: One of which does the whole Year round obſerve in a manner one and the ſame Courſe, always blowing from the ſame Quarter, without any Obſervation of any Return, or of any contrary Wind; and theſe are named by Mariners and Geographers, *Paſſage* or *Trade Winds*. Thoſe of the Second Sort are ſuch as they call by the Name of *Monſoon* or *Mouſoons* (in Latin *Motiones*) and theſe blow one half Year from one Corner, and then another half Year from that Quarter of the Heavens directly oppoſite.

Without theſe Trade-Winds, how could they ſail upon the great Ocean? How could there hardly any Ship arrive at the *Eaſt-Indies?* Since at ſome Degrees North of the Equinoctial you meet with a South-Eaſt or Trade-Wind, which, being in a manner directly contrary, does perpetually reign there; and as near as a Ship can ſail againſt or bear up to the Wind, as they term it, drives it upon the Coaſt of *America* and to the *Abrolhos*; and whereas they endeavour to ſteer their Coaſt Eaſtward, they ore obliged to make away ſo far to the Weſt, that they may get out of the reach of theſe Trade-Winds. Being come ſo far, they are brought by changeable Winds to the *Cape of Good Hope:* From whence ſailing into the 38th, 39th, and 40th Degree of Southern Latitude, they meet with another Trade-Wind, which blowing almoſt contrary to the former, and to the Northward of the Weſt (for which reaſon it is called the Weſterly Trade-Wind) carries the Ship to the Journey's End; and that too with ſo great a Force ſometimes, that according to the Obſervations which a very curious Mariner communicated to me out of his Journal, his Ship was driven by this Wind above 50 Leagues to the Eaſtward in the ſpace of 24 Hours And when the Ships return from the *Eaſt Indies*, the firſt South-Eaſt Trade-Wind is again ſerviceable to them, to carry them ſome Degree North of the Line.

SECT. XXIV. *Convictions from the foregoing Obſervations.*

I HAVE often conſider'd with myſelf the great Advantages that accrue to the *Dutch* from their Travelling in *Trek-Schuits*, or Boats drawn with one or more Horſes; by which they can in a manner, throughout the whole Country, compute exactly the Time required to paſs from one Place to another, let the Diſtance be what it will.

Will now any Atheist, how obdurate so ever he may be, dare to maintain, that those who alone enjoy the Conveniency thereof, are not the least obliged to the Prudence and Foresight of their Governours for it; who have been pleased to appoint the same for the Publick Good, in order to render the Correspondence of one City with another the most cheap and convenient to the Inhabitants? And that those have most Truth on their Side, who affirm, that it is by mere Chance, or at least, without any View or Design, that at every time, and as often as it is required, fresh Horses are at hand to draw the said Boats?

Now if we were to use no other Arguments; might not this Constancy, in such uncertain and variable Motions as are those of the Winds, convince every reasonable Person, that the Creator and Ruler of all Things, has thereby proposed to himself certain principal Ends and Purposes? For if variable Winds and Calms should indifferently reign in all Parts of the Ocean, what Computation could be made of bringing a Voyage to any sort of Conclusion? And how many unhappy Seamen being detained in these long Voyages by Calms or contrary Winds, would run the Risk of perishing with Hunger and Thirst.

Let no body think that we carry this our Assertion too far; because the great Creator of all Things, in order to stop the Mouth of these blasphemous and deplorable Atheists, and to deprive them of all Evasions, and sheltering themselves again behind a necessary Consequence of ignorant and natural Causes, has shown them that it was in his Power to have govern'd the Winds after a quite different manner; and particularly to have render'd the Seas impracticable and unnavigable by Calms and variable Winds.

For a Proof hereof, we shall make use of the Words of that great Mathematician, the present learned Professor of Geometry at *Oxford*, Dr. *Edmund Halley*, who, after he had been a long time between the *Tropicks* upon the Island of *St. Helena*, and having made the diligent Enquiry into the Nature of the Winds by all possible Means, informs us (as we find it in the *Philosophical Transactions Numb.* 183.) that about the Coast of *Guinea* he observed many Calms and *Tornado's*, which are terrible Winds, and run round the whole Compass, and then he proceeds, Sect. 7. *that between the fourth and tenth Degree of Northern Latitude, between Cape* Verde *and the Eastern Islands, of the same Name, there is a great Extent of the Sea, of which it might be said, that there did not blow any, not even variable Winds at all; and that the Sea seemed to be condemned to a perpetual Calm, and was attended with dreadful Claps of Thunder and Flashes of Lightning, and great Storms of Rain. The Winds that are there did only deserve the Name of little uncertain Blasts, shifting hourly, and before they shifted, becoming Calm; so that several Ships before they could sail 6 Degrees, or about* 120 *Leagues, were obliged to spend whole Months* (*Varenius*, in his Geography, *Lib.* I. *cap.* 21. §. 16. says three at least) *for want of a Wind.*

They that would be further informed of the Properties of these Winds, may meet with a great many Observations and Discourses concerning them in the Works of the learned Lord *Bacon*, *Varenius*, *Mariotte*, and the so called Sea-Charts or *Atlas*; particularly all that relates to *Trade Winds* and *Monsoons*,

Monsoons, is very accurately described by the said Ingenious Dr. *Halley*, and may be found in the abovemention'd *Philosophical Transact. Numb.* 183.

SECT. XXV. *A Brief Description of the said Winds.*

To inform a general Notion of this, let any one place before himself a Globe or Map of the World, and view that Zone that is contained between the Tropicks on each side of the Equinoctial, as Dr. *Halley* has represented it; They call it the *Torrid Zone*, by reason of the Heat. Here he will see, that the Waters of the great and general Ocean may be consider'd as divided into three Parts, by the Intervention of Lands: The first is the *Ethiopic* and *Atlantic Sea*, between *Africa* and *America*; to the Eastward there lies the Second or *Indian-Sea*, between *Africa*, the *Indian Islands*, and *New-Holland*; the Third is the great *South-Sea*, or *Mare Pacificum*, extending itself from the *Western* Coasts of *America* along the other side of the Globe quite to the *Philippine-Islands*.

Now according to the Observations of Dr. *Halley* and others, we find:

I. That between the *Tropicks* in the *Atlantic* and *Ethiopic*, as also throughout the whole *South-Sea*, there always blows an Easterly Trade-Wind, which South of the *Equator* is something Southerly, and North thereof somewhat Northerly.

II. That these Trade-Winds do not reach farther than to about 30 Degrees on both sides of the *Equator*.

III. That however there continually blows a South-West Wind about the Coast of *Guinea* upon the Land.

IV. That the Southern Part of the *Indian-Sea*, the Wind blows always from the East or thereabouts, with as much Certainty as in other Seas. So that a constant Easterly Trade-Wind, and which surrounds the Globe, is found at all times in the Places before-mention'd.

V. But it is very wonderful, that on the Northside of this said *Indian-Sea*, the Winds which do one half of the Year blow continually from the East, as in other Seas, turn again the following half Year, and blow directly contrary from the Western Parts of the Heavens; and these are called the *Monsoons*. As for the other Particulars of those Winds, mention'd in the aforesaid Quotations, we shall pass them by.

SECT. XXVI. *Transition to Experiments about the possible Causes of the Winds.*

IT will not then be necessary for us to make a great shew, as some do, of the Knowledge we have either acquired our selves concerning these Winds, or have learned from other People: But it seems best to adore the Great Director in his unscrutable Ways and Works, as despairing ever to attain to Perfection herein. However, since a great many things appear to be sufficiently known concerning the said Winds (tho' it be very little in it self, with respect to the Importance of the Matter) to prove from thence the Wisdom and Power of the Creator; that we may not pass by all of them untouched, but furnish some Opportunity to such as have any Inclination to

make further Enquiries therein, we ſhall briefly propoſe a few Experiments, which have been, and perhaps may ſtill be uſeful to many, either for a Foundation, or at leaſt ſome Direction in their Thoughts and Diſcourſes about them.

SECT. XXVII. *The firſt Experiment touching the Contraction of the Space in in which the Air is contained.*

SINCE the Eſſence of the Winds conſiſt in a Motion or Protruſion of the Air from one place to another, it is certain, that whatever is capable to protrude the Air after ſuch a manner, is likewiſe proper to cauſe a Wind. Accordingly we find;

I. That the Air may produce a Stream and a Wind when it is ſhut up any where, and the Place containing it is render'd narrower; whereupon being preſſed, it forces its way thro' all the Paſſages it meets with, and thereby repreſents a Blaſt or Wind.

This we may ſee when a Man blows with his Mouth, or preſſes a pair of Bellows, or in the ſudden fall of things that have any Breadth in them, whereby they preſs the Air between them and the Ground, and driving it away on every ſide, produce a ſort of Wind. This way of generating a Wind was known to *Hero Alexandrinus* many Ages paſt, by making of a hollow Veſſel that was Air tight, and had two Tubes, a great and a little one: Thro' the greater there runs Water with ſome Swiftneſs into the Veſſel or Ciſtern, which aſcending in the ſame, contracts the Space wherein the Air was contained, and ſo forces the ſaid Air with a Blaſt thro' the narrow Tube, by which means little Flutes, Pipes of Organs, and Figures of Birds are made to yield a Sound? to ſay nothing of blowing Fires, and even ſmelting Metals in ſome Places after the like manner.

SECT. XXVIII. *The Second Experiment with a hollow Globe or Æolipile.*

II. SOME Philoſophers (upon obſerving the Experiments of heating a hollow Braſs Globe, having a little Orifice or Hole in it, and then throwing it into cold Water, to cauſe the Water to go into it, and afterwards making it hot again over a Fire, whereby the Vapours ruſh out like a violent Wind) have thought that the Wind does not ſo much conſiſt in a Motion or Protruſion of the Air as in Watry-Vapours, which this Experiment of an *Æolipilo* or *Wind Globe* confirms; and have therefore endeavour'd to deduce all the Properties of the Wind for the moſt part from ſuch Experiments. But we ſhall not here enquire either into the Probability or Difficulties of their Hypotheſis. [See the Figure of ſuch an *Æolipile*, *Tab.* XXII. *Fig.* 3.]

SECT. XXIX. *The Third Experiment, The moving of the Solid Bodies through the Air.*

III. ANOTHER manner of moving, or producing a Stream of Air, is by cauſing a Body to paſs ſwiftly thro' it; foraſmuch as by that means the

the Air follows the ſaid Body with a great Velocity, and riſes a Wind behind it.

To make a very eaſie Trial thereof, one need only extend ones Hand, the Fingers being cloſed, and ſwiftly ſtrike upon the Air from one ſide to the other; whereby one ſhall be aware that the following Air ſenſibly blows againſt the opening of the Hand, eſpecially if you moiſten the ſame with a little Water, for then you will more ſenſibly feel the ſame.

But to give a viſible Proof thereof, drop ſome little round Bullets from any due Height into a Bucket of Water; and as ſoon as they fall to the Bottom, you will ſee ſome Bubbles of the Air that followed 'em riſing up from the Bottom to the Top of the Water; inſomuch, that many times if the Bullets deſcend from a greater Height, and conſequently with more Swiftneſs, the Bubbles will even be as large as the Bullets.

The ſame has been obſerv'd in the Force of the Wind, which ſome have felt to their Harm, upon a Cannon-Ball's paſſing very near them, yet without touching them.

'Tis the like Sort of Wind, as ſome think, that is excited by the ruſhing of great Hail-ſtones, as they ſwiftly deſcend.

Sect. XXX. *The Fourth Experiment; Effervescences.*

IV. We ſee a Wind likewiſe generated by mixing together two Effervescent Matters, and cauſing them to ferment; and it is the ſame thing, whether both of them be liquid, or one of them be a ſolid Body.

Accordingly, if you throw Filings of Iron or Steel into Spirits of Salt-petre, or into *Aquafortis*; or if you mix with the Spirit of Sulphur, Sea-Salt, Copperas, or any other Acid Spirit, an Alcaline Liquor, ſuch as Spirit of Sal-Armoniac impregnated with Potaſh, or Spirit of Hartſhorn, Salt of Tartar, or Potaſh itſelf diſſolved in Water, they will produce a Fermentation with great Violence, and exhale a Stream of Air and Vapours out of the Mouth of the Glaſs or Veſſel that you put them in; of the Force of which Fermentation or Ebullition you will be the more ſenſible, if you ſtop the Mouth of the Glaſs for a little ſpace, whilſt they are working together; but you muſt not keep it ſhut too long, for unleſs the Glaſs be very ſtrong, it will burſt in pieces as if Gun-Powder were kindled in it.

We do not here enquire after what manner the Wind is thus produced, being ſufficient to our Purpoſe, that a Wind can be ſo made; and that ſuch an Effervescence may be produced among the like Particles, even in the Air itſelf, has been in ſome ſort proved above in §. XIX. about *Fogs*.

Sect. XXXI. *The Fifth Experiment, by burning Sulphureous Bodies and Salt-Petre together.*

V. Some Naturaliſts are wont to add to theſe Winds, the very violent and turbulent Protruſion of the Air and Smoak that has been obſerved by the mixing of Salt-petre with ſome Sulphureous Matters, and touching them only with a little Fire.

After this manner, we ſhall ſee an Inſtance of it in mingling Antimony with Salt-petre, or (if we fear any Danger from the Smoak ariſing from this Mixture) by mixing powder'd Salt of Tartar with the like Quantity of Salt-petre, and then ſetting it on Fire with a live Coal, or red hot Iron, eſpecially if you burn theſe Matters incloſed in a Veſſel, out of which their Smoak may have a Paſſage thro' a Tube, as the Chymiſts do upon certain Occaſions: for then you will ſee with how much Force and Swiftneſs there will be a Wind and Stream of Air produced.

Some ſuppoſe that the *Hurricanes* are generated in this manner, by the inflaming of ſome ſuch Matters in the Earth. *Firſt*, Becauſe of the great Force and Violence of them, which muſt proceed from a very great Velocity of the Air-Stream, which upon this occaſion is very remarkable. *Secondly*, Becauſe they do not laſt long, and commonly not above 7 or 8 Hours. *Thirdly*, Becauſe they are obſerv'd to rule for the moſt Part in certain Places only. *Fourthly*, Becauſe (as we ſee in the aforeſaid Burning Matters) the Streams of Smoak diffuſe themſelves on all ſides, and ſo the Wind blows from all the Points of the Compaſs. *Fifthly*, Becauſe Earthquakes are often felt at the ſame time in the adjacent Places, and dead Fiſhes found floating in thoſe Parts of the Sea that are neareſt.

Now, that theſe Fires produced by Salt-petre and Sulphur, tho' kindled under the Bottom of the Sea, are not extinguiſhed by its Waters; and that the Smoak thereof forces its way upwards thro' the ſame, may be eaſily accounted for by the Fire-works, that perform their Operations even in the Water, where they will remain a great while, without being extinguiſhed, and from whence Men may ſee the Smoak of them aſcend. The ſame thing will appear as plainly, by kindling a little Squib or Serpent, as they call it, and throwing it into a Glaſs full of Water, where you will perfectly ſee the Squib burning out, and all the Smoak of it riſing thro' the Water, inſomuch, that if any Fiſh were there, 'tis likely they would all die.

Whether this be the true or only the probable Cauſe of thoſe dreadful Winds, which they call Hurricanes, we ſhall not enquire any farther here.

Sect. XXXII. *The Sixth Experiment, ſhewing, that the Elaſtick Power of the Air being augmented, produces Winds.*

Besides the foremention'd Cauſes of the Production of Winds, the great and principal Property of the Air does ſtill furniſh us with another; which, tho' unknown till of late Years, is yet eſteem'd by many, and with great Appearance of Truth, in this Age, for one of the Cauſes of Winds. This has been ſhewn before in the particular Account which we have given of the *Elaſtick* Power of the Air; by which it continually endeavouring to dilate itſelf towards every Part where it does not meet with a ſufficient Reſiſtance, breaks forth with a great and ſwift Stream; inſomuch, that when we take away the Balance of Force, by rendering one of the two adjacent Airs ſtronger, or t'other weaker, the ſtrongeſt always expands itſelf towards the weakeſt, and by protruding or driving it forwards, cauſes that Motion which we call Wind.

VI. The

VI The Particles of the Air press upon one another in a Wind-Gun; by which means their Elasticity is augmented; and we may see that it will drive out a Bullet, notwithstanding the Resistance of the common and external Air, with such Velocity as is now well known to the Amazement of many.

After the same manner, if you blow Air strongly into a little Bottle with a narrow Mouth, and give it room to flow back again, you will find that it will rush out from thence with great Swiftness, tho' it was a long time in blowing in, only because it is strongly compressed within that narrow Space. Now whether certain Sorts of very violent Winds do suddenly exert themselves like Gusts and Blasts, after the same manner, because two other more gentle Winds driving before them all the Vapours and Clouds in the Air, and blowing them against each other, do compress the interjacent Air, and dispose it so as to break out with a great Swiftness, for want of a sufficient Resistance, we shall leave the further Enquiry to such as think it worth their while, and may meet with Opportunities of making it.

SECT. XXXIII. *The Seventh Experiment; the Diminution or Weakning of the Air will produce the same Effect.*

VII. Now, as we have shewn from hence, with how great a Velocity the Air can be protruded as it becomes stronger in its Elastick Faculty, it being thicker and closer compressed in the same Place; the same Velocity does likewise exert itself when the Balance of the resisting Air only is taken away either in whole or in Part, by diminishing the Quantity thereof in any Place.

Thus we see when a *Vacuum* is made by exhausting the Air, the common Strength of the external Air forces in with very great Swiftness. Several Experiments proving such a strong Blast, have been already quoted upon the Subject of Respiration.

Those who desire to see more Proofs may consult the Machines of Messieurs *Guerike* and *Papin*, (*Philosoph. Transact. Numb.* 121.) with which, in the Presence of *the Royal Society of London*, the same Force and Noise was in a manner produced by the rushing of the Air into a *Vacuum*, as is usually made by the compressed Air in a Gun, being let out.

However, if those that have neither an Air-Pump, nor such Machines as these at hand, are desirous to make this Experiment, namely, that the Air forces itself like a violent Wind into a Place where the internal Air is either much diminish'd, or has very little Elasticity in it: Let them take a Glass Bottle, first putting a little Water into it, and tying a wet Bladder over the Mouth of it; so that turning it upside down, there may be about the Quantity of two Fingers breadth of Water in the Neck of it; then turning the Bottle right again, that the Water may descend to the Bottom of it, and the Neck remain empty: Let them make a little Hole in the middle of the Bladder, with a Pin or Needle, and through the same suck out the Air from the Glass, as strongly as they can for several times; stopping the Hole at every turn with the Finger, that no Air may get in again,

When this is done as well as it can be, let the Bottle be inverted again, so that the Water may run into the Neck, and upon the Bladder stopp'd with

the Finger; upon the removing of which Finger, the External Air, like a Wind will ruſh into the Bottle thro' the Hole of the Bladder and the Water lying upon it, and riſe up to the Top, where the Internal Air had been diminiſh'd and weaken'd by Suction.

Now, if according to the Calculations of Mathematicians, the Air, which forces it ſelf into a *Vacuum*, moves with ſo much Velocity, as to advance 1305 Foot in a Pulſe, or Second of a Minute, (See *Philoſophical Tranſactions.*) And according to the Obſervation of the accurate Mr. *Mariotte*, it is very difficult to withſtand, or advance againſt a Wind that moves 24 Foot in a Second; and that another, that runs 32 Foot in the ſame time, produces ſuch a Storm, as is capable of tearing up Trees and overturning Houſes: (See his Diſcourſe *du Movement des Eaux*, *p.* 67. *and* 78. *See likewiſe the ſaid Treatiſe lately done into* Engliſh, *by the Ingenious Dr.* Deſaguliers.) What Havock and Deſtruction of every thing might we not expect from the terrible Force of a Wind, which being above 40 times as ſwift, would, ſuppoſing it to act upon the ſame Bodies, exert 40 times as much Strength as the aforementioned Storm, eſpecially, if that Air which ſurrounds the whole Globe ſhould have the Opportunity of diſplaying its Elaſtic Power upon any great Space that were almoſt or altogether empty of Air? Now, whether ſuch a thing may be ſuppoſed to have ever happen'd, and whether Winds have been protruded after the like manner in the open Air, we ſhall not here enquire.

But this however may be plainly inferr'd from what has been ſaid, that the Preſſure of the Air being enabled to exert itſelf with its utmoſt Force, would, by its exceeding Swiftneſs, produce moſt dreadful Effects; deſtroying every thing upon the Face of the Earth, in a very little Space of Time, as has been already ſhewn in *Contemplation* XVII. by an Experiment of the Air's breaking a Glaſs, tho' the ſame was far from being exhauſted of all its Air.

Sect. XXXIV. *The Eighth Experiment; Of producing Wind by Cold.*

VIII. We have ſeen that the abovemention'd Motion of the Air or Wind was produced, by diminiſhing the Quantity or Strength of the Air. But beſides this, there is another Caſe in which, tho' the Quantity of the Air be not diminiſhed, yet the Elaſtick Faculty thereof is weaken'd; namely, when one Air is only colder than another, which in every thing beſides may be like to the firſt: By which means alſo a Wind is generated when the leſs Cold, and therefore ſtronger Air, expands itſelf, and preſſes upon the more cold and conſequently weaker Air.

Many Experiments proving the ſamer are well known to the Naturaliſts; and the Operation of the Thermometers, which are moved by Rarefaction and Condenſation of Air, do frequently ſhew the ſame.

But to give a very eaſy Proof hereof, you may try the following Experiment: Bind a wet Bladder upon the Mouth C D, of a Glaſs Bottle F G C D, (*Tab.* XIV. *Fig.* 6.) after having pour'd ſo much Water into it, as will not quite fill the Neck K C, when the Bottle is inverted. Then take a

ſecond Bladder HKLI, cutting off the Neck of it in ſuch a manner, that the Orifice HI, may be very large; then having made a Hole in it at KL, the Neck KLCD, will thereby go thro', and the Bladder at KL muſt be tied or twiſted very cloſe about it. After which throwing in a handful of Salt, and one or two handfuls of Snow into the Bladder HIKL, upon the globular Part of the Bottle FGKL, ſtir the ſame together with a Stick or Spoon; when, as it is well known, the Snow will begin to melt, and the Air in the Bottle, which is encompaſſed with this Mixture, will become very cold; and the Water itſelf, if it were higher in the Neck of the Bottle than KL, would eaſily be frozen, which might embarraſs the Experiment, and for that reaſon the Water ought not to be higher than AB, or below the Bladder KL. Now that the Air in the globular Part of the Bottle FGKI, is weaken'd in its Elaſtick Faculty by this Cold; and that the External Air, which is not ſo cold, being enabled to act upon it, will expand it ſelf with greater Force, and produce a Wind, blowing upon the colder and weaker Air at P, may appear by pricking the Bladder CD with a great Pin at E; whereupon one may ſee the Air forced through the Water ABCD, that is in the Neck of the Bottle with a remarkable Velocity, like a Wind, up to the globular Part FGKL.

This Experiment having been likewiſe tried in the great Froſt, upon the 12th of *January*, 1709, 'twas obſerv'd, that as cold as the Air was then, yet by this Mixture, and by the greater Cold, it loſt ſtill more of its Elaſtick Power; and the External Air being ſtronger, ruſhing like a Wind thitherwards, ſhewed, that a great Quantity of Air may be ſqueez'd together in a cold Place. That which might probably be inferr'd from this Operation of the Cold upon the Air, concerning Winds, ſhall be treated of in ſome manner hereafter.

SECT. XXXV. *The Ninth Experiment; Of Wind produced by Warmth.*

IX. THE Operation of Warmth is directly contrary to the foregoing; dilating the Air with greater Force, thereby producing a Current of Wind towards all the Places, where it meets with no Reſiſtance.

This might likewiſe be ſhewn by the Thermometers, in which the Warmth expands the Air; but to repreſent it to thoſe that have no Thermometers at hand; Set again a Bottle, in which there is nothing but Air, with the Mouth turned downwards upon a Plate or Diſh, upon which you muſt pour as much Water as may riſe juſt above the Brim of the Mouth of the ſaid Bottle, and thereby prevent any Communication between the External and Internal Air. Now if you hold a Burning Coal, and move it round the Globular Part of the Glaſs upwards and downwards, ſo as to warm the Air within it, you will ſee that the rarified Air ruſhing out in little Bubbles between the Bottle and the Plate, will produce a ſoft and gentle Wind.

If you have a mind to ſee this Experiment confirmed with a ſtronger Blaſt, you muſt apply a more ſudden and violent Heat thereto; as may be eaſily done, if you make uſe of a Bottle encompaſſed with a Bladder (*Tab.* XIV. *Fig.* 6.) and leaving it open at CD, ſet it down upon a Plate,

with Water, then pour hot Water upon the bottom of the Bottle F G, and all round it, with some Care least it burst; this increased Heat will produce a swift Current of Air, or Wind made by the Air, which rushes out as it is expanded.

SECT. XXXVI. *The Tenth Experiment; Wind produced by the Suspension or Cessation of Warmth.*

X. BUT forasmuch as by the driving out of the Air by Warmth, the same is diminished in the Bottle, and therefore, when the Warmth that had driven it out ceases, the Expansive Faculty will become weaker than it was before, whilst there was a greater Quantity of Air in the Glass, and whilst it had a Communication with the surrounding Air. It will therefore follow, that the External Air (having the same Degree of Cold or Heat with that which was included in the Bottle, and was diminished in its Quantity by the foregoing Warmth, will pass more strongly that way, and so crowd itself into the Bottle with a returning Wind. One that understands Hydrostaticks, might demonstrate the same in the preceding Experiments; forasmuch as the Air within the Bottle losing its greater Heat, the Water will rise up into the Neck of the said Bottle from the Plate, by the Pressure of the External Air, But as this is writ for the sake of the Ignorant, to make them even see the aforesaid returning Wind, put into a Bottle again as much Water as will fill the Neck when it is inverted, thereby to render visible, is above, the Discharge of the said Wind thro' the Water; then hold the Bottle for a while over the Steams of boiling Water, to the end, that the sudden Heat may not burst it, and finally put it into the boiling Water itself, till it be very hot, and the Air rushes out by the Mouth of it, which is open as is done above in *Sect.* XXV; then take a warm wet Bladder, and tie it as close as you can upon the Mouth of the Bottle, and invert it so, that the included Water may lie upon the Bladder, then set it by, for a little while in the same Posture, till the Internal Air lose its Warmth, and become equally cold with the External. Now if the Bladder be tied close enough, the Expansive Power of the Air, which is in the Bottle above the Water, will become weaker than that of the External, because the Quantity of the Air is diminished, and is therefore more rarified: Wherefore in case the External Air, which is strongest, can operate against the other, it will be driven with a Current or Stream against the rarified Air; which may be discover'd by making a Hole in the Bladder with a Pin, whereupon you will immediately see the External Air, like a Wind, rising up thro' the Water.

Now, whether from all these Properties of the Air, and from the Heat of the Sun operating thereupon, the Easterly Trade-Winds, and in some measure likewise, those that blow from the South in Spring and Summer, and from the North in Autumn and Winter, may be truly prov'd according to the manner of the modern Naturalists: Those that are curious, may enquire by consulting them.

SECT.

SECT. XXXVII. *The Eleventh Experiment; Wind produced by the Motion of the Air upwards.*

XI. THERE is still one other Motion and Current of the Air, mention'd by Dr. *Halley*, in his Discourse about the Winds, (See *Philosph. Transact. Numb.* 183.) by which it acquires a Process upwards; namely, when the Air, being rarified by Warmth or otherwise grows thinner, and consequently lighter in the same place than when it is compressed and increased by Cold (as it has been shewn upon other Occasions;) it follows therefore, that in case the Warmth descends perpendicularly from the Sun, there will be produced directly under it, a streight ascending Column in the Air, as far as the great and descending Heat extends itself; in which Column the Air will be much lighter than that which is about it, and which has not so much Heat. Now if we look upon this thinner Air as Oil, and the surrounding colder Air as the Water, every Body must own, that as a Column of Oil placed in the middle of Water does emerge, or is driven upwards, and according to the Laws of Gravity, diffuses it self upon the Surface of the Water, the same Appearances will likewise happen in this rarified Air. Dr. *Halley* uses this Comparison, to give us some kind of Notion, tho', as he owns himself, a very imperfect one, of the Motion of the Air in the *Monsoons*.

In order to support these Arguments by Experiments, and to render in some manner visible such a Current and Wind produced in the Air; take a little Glass, E F K L, (*Tab.* XIV. *Fig.* 7.) about six Inches high, and the Mouth of it between two or three Inches broad; set it upon a Table, then take a lighted Pipe of Tobacco, and put the Bowl of it in your Mouth, cloathing it with Paper, if it be too hot, and put in the little End of it at I or K, upon the Bottom of the Glass, and blow the Smoak of it as hard as you can into the Glass, till it comes very thick out of the Orifice E F, and filling the Glass, renders it quite dark or untransparent, which it will do very soon; then take the Pipe out of it, staying till the Smoak in the Glass has in some Measure lost the chiefest Part of its Motion, and stands still like a stagnating or gently moving Water, and represents a kind of a Superficies above at A B; then take a Nail G C, about a large handful in Length, and hold it with a Pair of Tongues a little above the Point C, or a little higher, (having first made it red hot for that Purpose) and place it in a direct perpendicular Posture, as at G C; then, beginning, as at H, let the hot Point of the said perpendicular Nail gently descend from H to C; and you will see, as soon as the same is come from H to C, or to the Superficies of the Smoak A B, that the said Air and Smoak will creep along the Nail, and ascend in a direct Stream from C to L; which especially from C to D, or so far as it remains below the Brim of the Mouth of the Glass, will preserve its Streightness; and sometimes, even as high as at L, when the Air in the Room is very still, which otherwise is wont to scatter and disperse this Column of Smoak as soon as it rises above the Brim of the Glass. To all which Circumstances, as minute as they are, you must carefully attend, if

you would make the Experiment with its requiſite Niceneſs. Now what has been ſaid before is made good by this Experiment.

SECT. XXXVIII. *Convictions from what has been repreſented about the Air in general.*

NOW will any Body deny, that the Wiſdom of our Great Creator does in all theſe things far ſurpaſs the Thoughts of Men; who for ſo many Ages has been pleaſed to make uſe of ſuch various Methods, and perhaps of many more too, to turn the Air into Winds; tho' it is very certain, that the Knowledge of moſt of theſe kinds of Winds, yea, of all that owe their Origin to the Gravity and Elaſticity of the Air, and perhaps too of ſuch as are produced by Heat and Cold, has been concealed till lately from the whole World; and who can tell, but that thoſe that are ſtill hidden, may be reſerved for the Diſcovery of our Poſterity?

At leaſt, a generous Philoſopher may learn from hence to entertain very humble Sentiments of his own Knowledge, and to ſee the Fallacy and Sophiſtry of thoſe *ſtrong Minds*, who fancy they can fathom every thing. *Firſt*, Becauſe we have ſeen ſo many and ſo famous Naturaliſts in thoſe Times, treating with ſo much Certainty, and even with the Appobation of very learned Men, about the Winds; who, if the Experiments of following Years, touching the Motions of the Air, had been known to them, would have even been aſhamed of the Conceit of their own Skill therein. *Secondly*, Becauſe, as has been juſt now hinted, even in theſe our Times, in which the Grounds of the Knowledge of the Winds have been ſo much augmented by new Experiments, the greateſt Mathematicians and Enquirers into Nature, that ſpeak ſincerely, have openly confeſs'd how far they ſtill are from attaining to a true Notion of theſe things.

But if an unhappy Atheiſt cannot be yet brought by theſe Repreſentations of the Greatneſs of GOD, and of his own Meanneſs, to confeſs the Power of his Adorable Creator; let him (if this may in any wiſe contribute to ſet him right) I ſay, let him with us contemplate the Globe of the Earth Z F G (*Tab.* XIV. *Fig.* 3) and obſerve, that there are found upon the ſame ſo many humane Creatures at F, ſo many Beaſts at M, ſo many Fiſhes at V, ſo many Birds at X, ſo many Trees and other Plants at O, ſo many ſtately Palaces and other Buildings in Cities and Towns at P, ſo many Fires for the Uſe and Service of Mankind at Z, ſo many Ships at N, which may paſs from one end of the World M, quite to the other G: And to ſay no more, let him ſeriouſly conſider all the Wiſdom and Art wherewith each of theſe things have been made after ſo wonderful a manner: Further, let him ſuppoſe all thoſe Men and Beaſts to be without any Life or Motion; the Fiſhes diveſted of the Power of Swimming, the Birds of Flying, the Fire of Burning, the Trees and Plants of Growing; let him fancy all the Towns to be uninhabited, and all Communication between the moſt remote Countries interrupted for want of Shipping; Will not the whole Globe of the Earth, with every thing that is upon it, appear to him a moſt melancholy and moſt frightful Wilderneſs? But now if any one ſhould come and tell him, and convince him

too

too by ocular Demonstration, that it was possible to endow a certain fluid and invisible Matter surrounding this Globe with such wonderful Qualities, that by means of the same, so many Millions of Men, and other Creatures would live; that the Fishes which he now sees floating upon the Water, would subsist under them; that the Birds shou'd be able to fly, the Trees and Plants to grow for the Sustenance of such Creatures; that Fire would burn for the Preparation of Food, for Light, and a thousand other Uses; that Ships, tho' loaded with a most surprising Weight and Burden, would be carried to the remotest Parts of the World, by the Strength of the said invisible Matter; not to recount all the other Services that are render'd thereby to those who inhabit this Globe: would he not, after having seriously weighed all these things, confess the Discoverer or Inventer of such a Fluid, to be wonderful Wise? Or, could he imagine that this Matter, destined to so many different and important Purposes, was capable of acquiring by Chance, and without Wisdom, the Properties necessary to produce not only so many and such great Things, but of ranging and diffusing itself, of its own accord, quite round the World? And can he then continue to affirm the same of the *Air*, by which he lives, and from which he reaps so many Advantages, which does all this, and much more still? Especially if his Knowledge extends so far as to be able to compare the Structure of Men, Beasts, Birds, Fish, Plants, and other things; (of which something has been shewn already, and more will be hereafter) with the Air and its Operations, and from thence observe with what mutual or reciprocal Respects they have been created.

And if this do not yet suffice, since the abovemention'd Benefits of the Air do necessarily bring along with them this Inconvenience, that the Force which was requisite to make the said Air useful in some of the cases beforemention'd, is no less hurtful in others; and would destroy or crush to pieces wholly, or in part, most of the Buildings and other things; let him say, whether he still believes that it is by meer Chance, and without any Design, that there is throughout the whole Expanse of the Air so wonderful an *Equilibrium*, whereby every Creature that wants Air, can so safely enjoy it; and at the same time, be secured against its raging Powers by the same *Equilibrium*, or Balance.

Sect. XXXIX. *Convictions from the Meteors in particular.*

We have dwelt long enough already upon the *Air* and its *Meteors*; wherefore we shall adjourn what we had to say about *Thunder*, *Lightning*, *Rain*, &c. till we speak of *Fire* and *Water*.

Let me only here ask our deplorable Philosophers the following Question: In case it is by Chance, and without a wise Direction, that every thing happens in and about the *Air*, how can they without a mortal Dread contemplate the said Air, and the least Assemblage of Clouds and other Meteors therein, and not tremble when they think, that it is wholly accidental that the *Thunder* don't destroy them, the *Lightning* consume them, and the *Hail-stones* dash them to pieces; or that the dreadful Powers of Heaven being put

put in Motion do not reduce all things to their native *Chaos* and Confusion?

Once again, miserable Atheists! who if they live at ease must renounce their own Principles; since, if all things were fortuitous, this Danger would always be at hand; and since it is as great, nay a greater Wonder, that they live unharmed but one Day amidst these destroying Powers of the Air, than that the whole Globe of the Earth, and every thing upon it is not thereby overturn'd and confounded. How much more happy must not they even own those to be, who discover herein the Goodness of the Great Governor of the Universe; that this vast Sea of Air surrounding the whole Earth, in which they would otherwise meet so many Causes of their Death, does yet concur in keeping them alive; and that all the *Meteors* thereof produce Profit and Pleasure for them; that the *Winds* favour their Navigation, serving to to bring them the Treasures and Commodities of the other Quarters of the World, and are of infinite other uses to them; that the *Rains* cause their Fruits to grow; that the *Dews* do often supply the place of the same in great Droughts; that even the cold *Snow* itself tends to fertilize their Lands; that other inflamed *Meteors* purify the *Air* of unwholsome Vapours, and that in intolerable Heats, the terrible Fires of those otherwise so pernicious *Lightnings*, help to make it more cool and refreshing; that the Sound of *Thunder* is as the Voice of God, whereby many, who too little acknowledge a Creator, are, as one may say, awaken'd from a dead Sleep. Thus Histories do testify how the most God-forgetting Atheists, that the *Caligula's*, the *Nero's*, altho' the mighty Tyrants of the World, and placed above the fear of all things, have been forced, only upon hearing the Thunder, to confess in *Fact* what they never would have own'd in Words, namely, that they stood in awe of one that is higher than they? Let me in the last Place ask the Freethinkers (as they call themselves) whether in calmly comparing the internal Disposition of their Mind with that of godly Men, so contemptible in their Eyes, they be not convinced, that they have reason to prefer to their own Condition, the happy one of a poor simple old Woman that lived in a Village, who being ask'd how she could be so merry, as even to sing in one of the greatest Storms of Thunder and Lightning she ever felt, answer'd, *That she was well pleased, to think that the Lord of all the Earth did still vouchsafe to look down from Heaven, speaking in such a Voice to those who did not sufficiently acknowledge his Mercies to 'em, and putting them in mind of their Duty.*

This Incident has often caus'd me to wonder, how much these Reflections of a poor ignorant Creature could make her soar above the reach of the most exalted Philosophy, who, acquiescing in the Goodness of the Almighty Ruler of all things, found her self in such a Tranquillity of Soul, at a time when the dreadfullest Cracks of Thunder and Lightning, that seem'd to set the World on Fire, made the stoutest Heart to tremble. Let an Atheist think on these things.

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